Specifications Seismic System as part of the LOFAR Project

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1 Introduction

This document specifies the design and implementation of the seismic system within the LOFAR project. This document results from extensive testing at the Exloo test-site of LOFAR. From the "Project Plan of the Seismic Application in LOFAR" [1] this document refers to tasks 1.1 and 3.6.

The structure of this document is as follows: first an overview of the total seismic infrastructure will be given, before zooming in into the different components. The different components may have a hardware and software component, and will then be described separately. All fine details and detailed specifications of hardware and software are given in appendices in order to keep the discussion at a general level and come up with a readable piece of text.

2 Overview seismic system

In this section an overview of the total seismic system is given and described. It shows the different subsystems which are described in further detail in subsequent sections. This section describes in a general manner how the sensor network LOFAR is implemented for seismic applications.

In Figure 2.1 a drawing is shown which gives the over-all structure. The data start to be sensed by the sensors in the field. Locally, the data is converted to digital signals before they are sent over the LOFAR network to a central unit at the "Rekencentrum" of Groningen. There, the data are collected, (automatically) analyzed and pre-processed if necessary. Then, based on the application, the data is sent via standard internet to TNO and/or KNMI for storage, further analysis and interpretation. These two institutes then allow these data to be retrieved via standard internet by other users, such as the TU Delft.

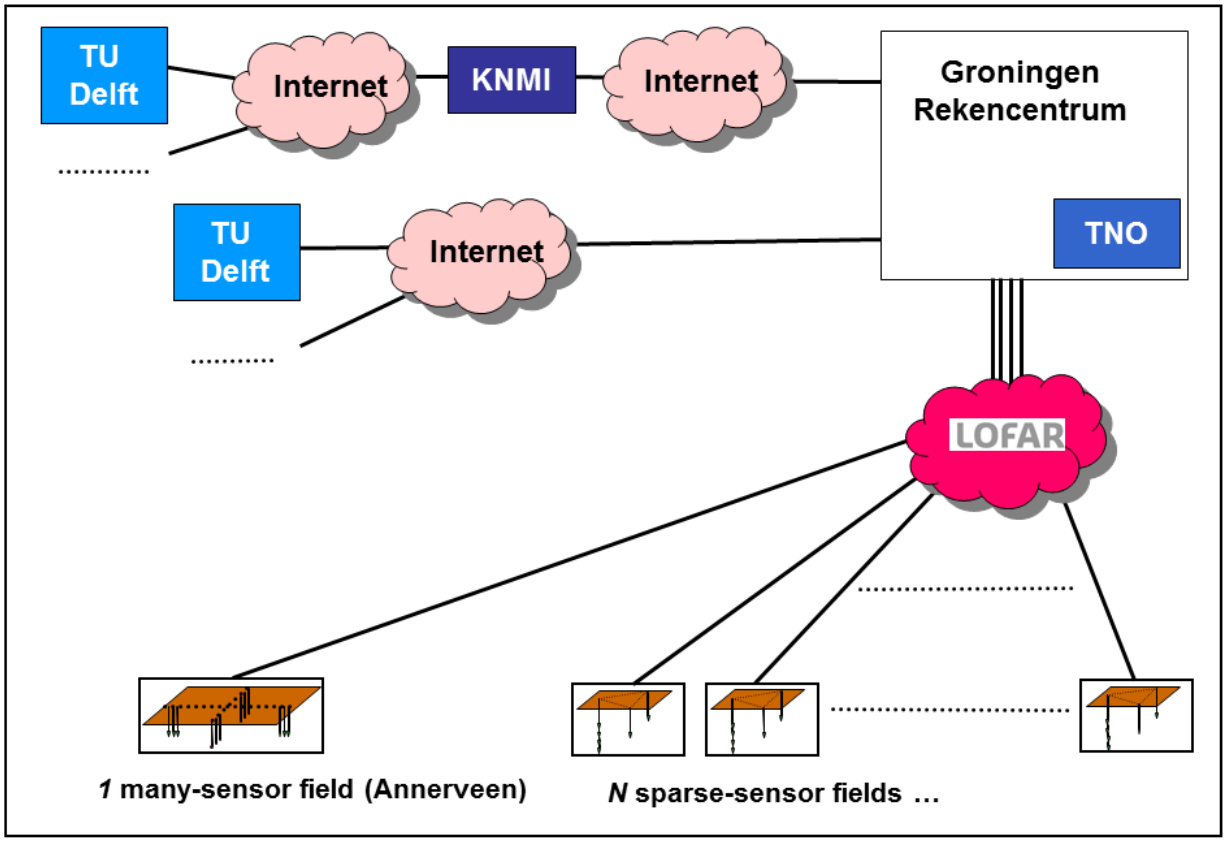


Figure 2.1. Pictorial overview of seismic system of LOFAR

The description so far dealt with the stream of data and not the control, such as parameter setting and testing. The control of the data and meta-data can be done locally on a sensor field, globally via the central server at Groningen or remotely via any place on the internet, although not all functionality is available at all locations. The functionality at each level will be described separately. For the description in the sections, the total system is divided into the following subsystems:

- local (sensor) fields
- central LOFAR network
- central system (Groningen Rekencentrum, with TNO facilities)

- data-storage and retrieval sites (TNO, KNMI)
- data access for users (e.g., TU Delft)

This will be done in the following, noting that the discussion on the first item, the local sensor fields, will be the most extensive one.

3 Local (sensor) fields

In this section the local sensor fields are further described in detail. First, the geometries as being used within the framework of LOFAR will be described. Next, the hardware will be discussed where its actual specifications are mostly given in appendices. Finally the software active on the local fields will be described.

3.1 Geometry of sensors

Two seismic geometries are planned:

1. A province-scale geometry that is making use of the fields as used by the astronomers as part of the LOFAR project. From a geophysical perspective, this geometry is focussed on the lower frequencies (< 20 Hz) and sparse sampling of the wavefield. This geometry can be used for inferring information of the deeper subsurface, and can be used for low-frequency interferometry.
2. A kilometre-scale geometry which is laid out on top of a seismically active field. This array will *not* be on one of the fields that the astronomers are using. Typically, this geometry will be similar to that being used by the hydrocarbon industry. A requirement for such geometry is that the wavefield needs to be properly sampled. This geometry focuses more on the higher frequency bands, up to 100 Hz. This geometry is most promising for the passive interferometric technique to work. Also for monitoring for the changes in the subsurface, this geometry is the proper way to do it. Although this set-up will not be on one of the LOFAR fields, the network does need somewhere linking up to the LOFAR network where the facilities of LOFAR are again available.

For the province-scale geometry, most of the antenna fields of the outer core are used for installation of 3-component (3C) sensors. In one borehole, four 3C sensors will be placed at different depths: 30m, 60m, 90m and 120m. This geometry allows estimating the (apparent) velocity of different arrivals in the vertical direction, next to its polarization.

In order to estimate the 3D direction certain events come from, three other boreholes are made in which one 3C sensor is placed at 60 meters depth. These three boreholes are put at maximal horizontal distance from the borehole with the four sensors, and at angles of 120^{o}. The whole geometry is shown in Figure 3.1

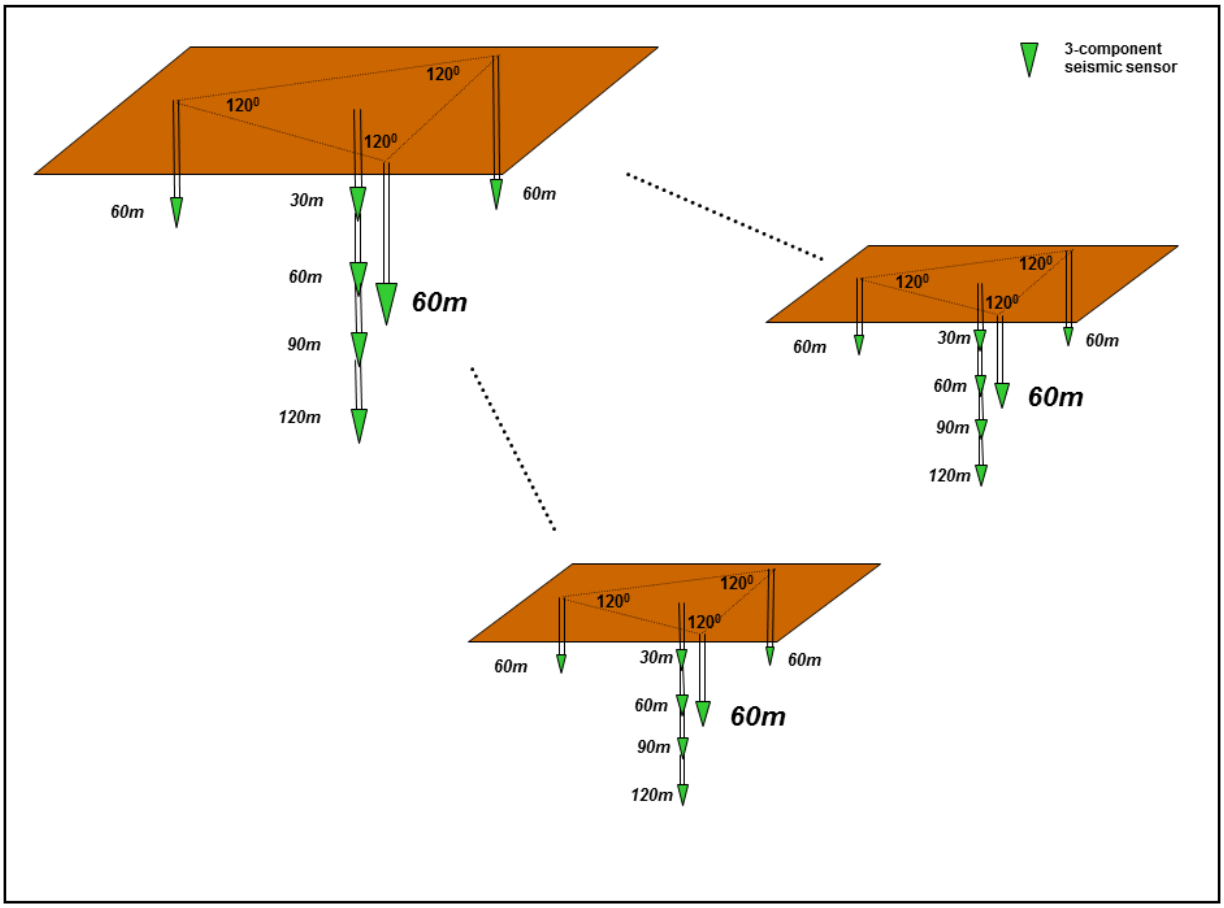


Figure 3.1 Configuration of 4C sensors for province-scale network at each antenna field (3 shown here)

For the local/km-scale geometry, the sensors will *not* be placed on any of the antenna fields but somewhere on top of a producing gas field where induced seismicity is occurring. In the horizontal direction, the total seismic wavefield needs to be properly spatially sampled, and this requires a horizontal spacing of 12 m (Drijkoningen [2]). The sensors are at a depth of 50 m, again to minimize effects of surface waves.

For proper processing and interpretation of the data, 96 4C sensors are placed along one line. A line of 24 4C sensors are placed on a line perpendicular to it but with a spacing of 48m. In depth, one borehole in the middle houses 6 4C sensors, at depths of 5 m, 25 m, 50 m, 75 m, 100 m and 125 m. The whole configuration is shown in Figure 3.2. This network is linked to the LOFAR-internet connection

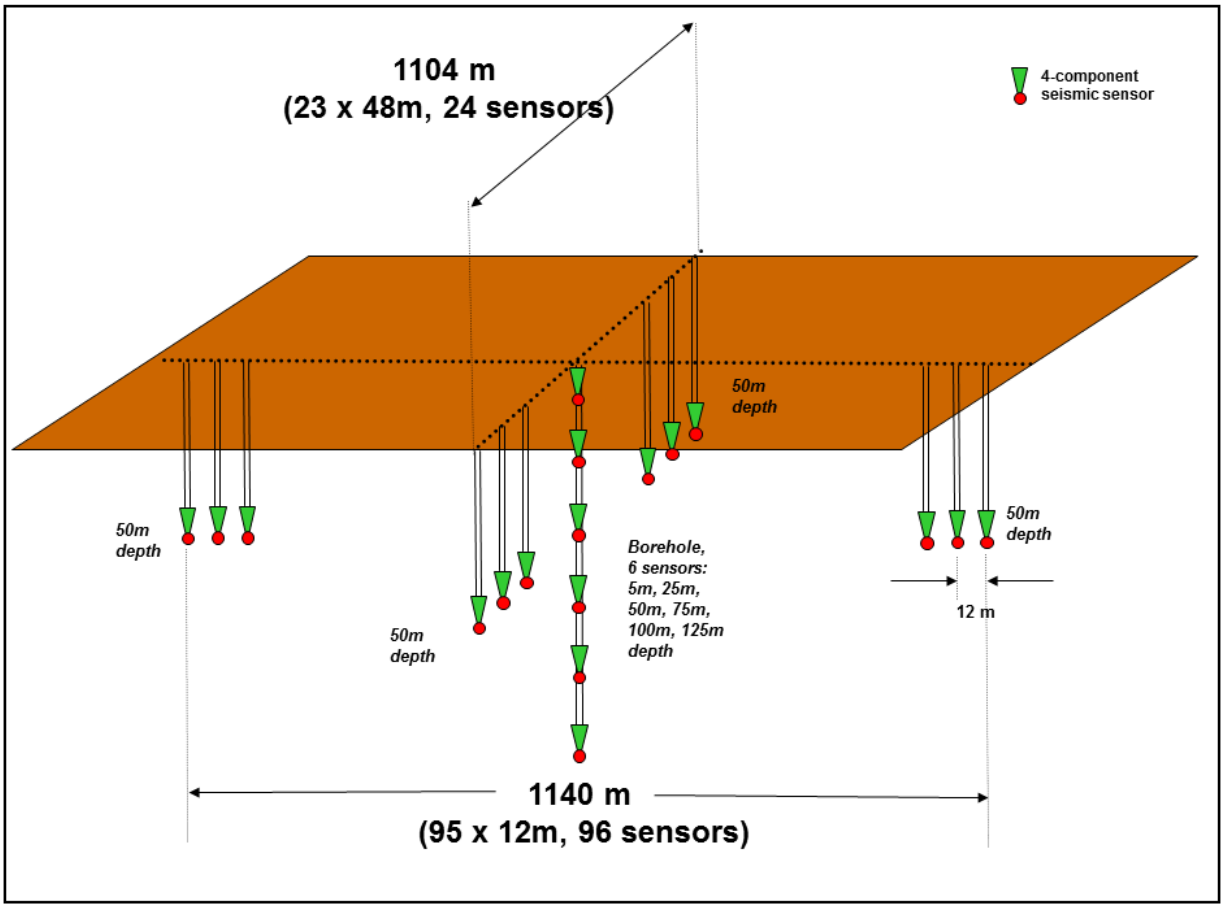


Figure 3.2 Configuration of 4C and 1C sensors for local/km-scale network.

For the final systems, most of the electric and electronics is housed in one cabinet. The hardware components are described in subsection 3.2. From a software point of view the systems are approached in the same way, and are described in subsection 3.3.

3.2 Hardware

Most of the electric and electronics is housed in one cabinet. An overview of a system is given in Figure 3.3.

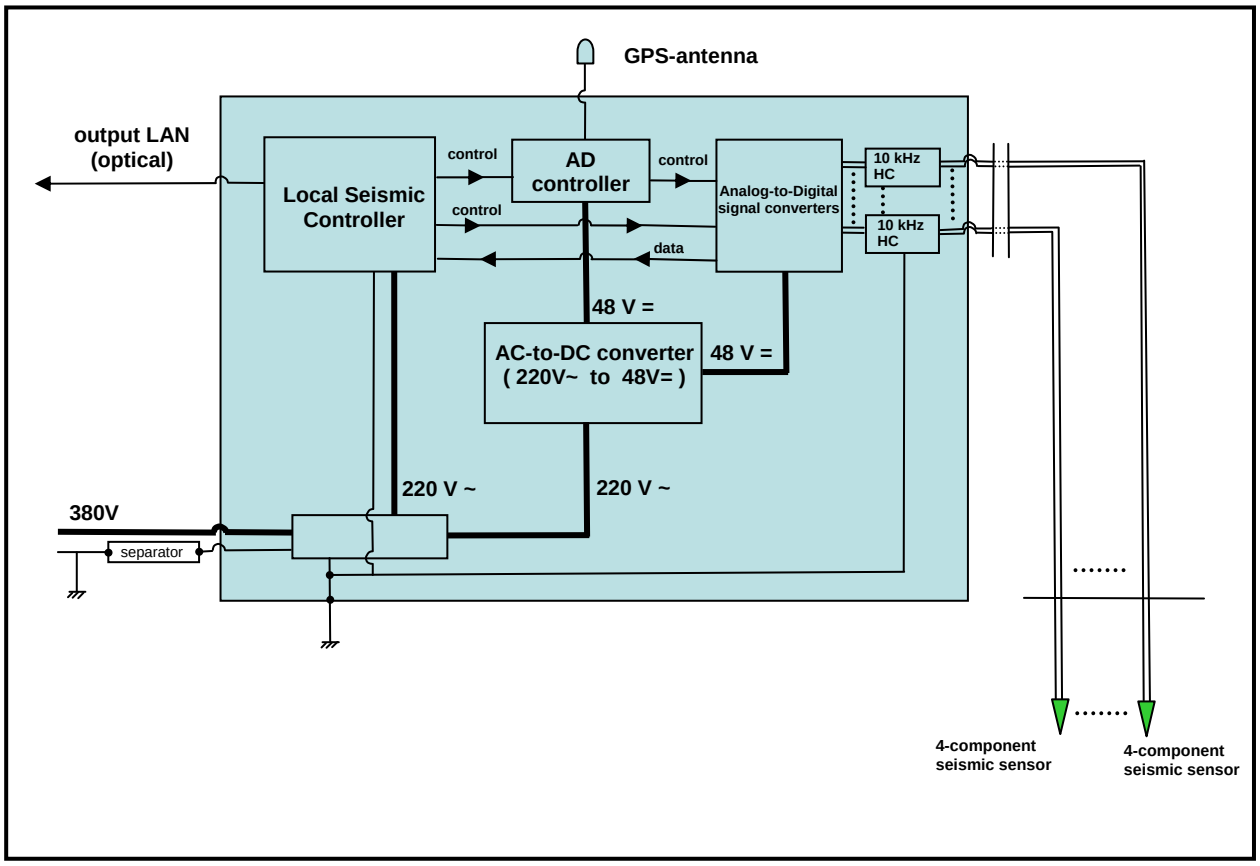


Figure 3.3 Overview of the province-scale network. Blue is the cabinet in which the electric and electronic equipment is housed.

The different components can be seen in this figure. The different components are briefly described in the following.

AC Power Supplies

The system is powered by a 380V coming from the local electric energy supplier (Essent). From one phase 220V is needed for local power.

Earth Wiring

Earth wiring is a very special issue since it is the most important noise source for the seismic monitoring. Separators and single earth-points are selected such that no undesired power runs over the earth-wires that pick up the 50-Hz signal from the central power supply. The central power supply is earthed, but separated by a separator from the earth of the cabinet itself.

DC Power Supply

The AD controller and AD converters use a DC voltage as energy source. In the case of the Exloo test-site these systems need 48 Volts. So a converter is included which converts the 220V AC-current to a 48V DC current. This system itself is using power from the local AC power supply (220V)

AD controller

This is a local piece of electronics that is supplied by a vendor so it is off-the-shelf. In the case for the test-site at Exloo, this was supplied by Geometrics Inc. This controller controls the AD converters and makes sure the data is properly transported. A specific task of the AD controller is to use a GPS clock to time-synchronize all AD converters on a common time-base.

Local Seismic Controller

This is the computer system from TNO on which the local software runs. The reason that there is this second controller is that some functionality of this off-the-shelf AD controller is still needed since this functionality was too cumbersome to develop within LOFAR itself (such as the test functionality which includes a signal generator.) However, because of LOFAR, a separate communication had to be set up, which would be independent of the seismic manufacturer. It was developed by TNO such that the software can directly communicate with the AD-converters and with the LOFAR network. The software is further discussed in the section on the software (section 2.3).

GPS antenna

The AD controller needs to get its time from the GPS satellites. Therefore an antenna is placed on top of the cabinet to pick up the GPS signal and transfer it to the AD controller. The AD controller uses this signal to synchronize all recordings on a common time base. This has been implemented by the vendor (so it is not known how this is done exactly). The accuracy needed is $1/10^{th}$ of a time-sample, so $1/10^{th}$ of 0.5 ms which is 50 μsec. The accuracy of the supplied system from the vendor is 10 μsec so it satisfies the needs.

AD converters

The AD converters convert the signals from the seismic sensors from analogue to digital ones. The input voltages for seismic vary tremendously. It is difficult to quantify what would be required to have a system that could cope with passive as well active seismic sources. It can be said that the current 24-bit systems are sometimes not sufficient since sources can be nearby (some tens of meters) as well as kilometres away. Especially for the application of seismic interferometry, it is not known what is needed. So the choice was for the highest possible dynamic range in the market, and those are the 24-bit ones. Mostly, they are from the Delta-Sigma type.

High-cut filters

Since the AD converters are conventionally of the Delta-Sigma type, they are operating in the MHz range. These types of frequencies are noise sources for the astronomy applications of LOFAR, working in the range of 10-240 MHz. Measurements at the test-site have shown that the AD converters radiate into the cables. In order to avoid these frequencies, high-cut filters are taken such that the high frequencies (above 10 kHz) are filtered out. This frequency is way below the minimum frequency of interest of the astronomers which is 10 MHz.

At the same time this 10 kHz is 100 times higher than the highest frequency of interest for the seismic applications which is 100 Hz. At this moment the high-cut filters are called “10 kHz HC filters” but the actual cut-off frequency will be slightly different in practice; the 10 kHz indicates the order of frequency where the cut-off will be.

Cables

The analogue signals from the seismic sensors are transported over a cable to the cabinet. At this moment, the only special requirement for the cables is that they are able to work properly

over 10 years and that they need to be below the frost region which is often taken as 60cm below the surface. Also, a cable placed at the surface is prone to damage, e.g. due to farming, and also therefore it is desired to bury the cables. Still, one would like to be able to retrieve and/or repair any damaged cable, so the cable should not be too deep. Therefore, it was decided to bury the cables at 1 meter depth.

In order to reduce cross-talk over the cable, especially the 50Hz and higher harmonics picked over the analogue wires, twisted-pair cables are chosen.

4C seismic sensors

The requirements of the sensors is that they are able to pickup both P- and S-waves. This requires the use of 3-component sensors. Then, a soil as encountered near the surface also contains water and/or air in the pores of the soil and pressure-sensors are able to pick up the energy in water. In testing at the Exloo site it turned out that data from sensors sensitive to the fluid pressure showed, as expected, lower levels of surface waves and higher levels of P-wave information. Therefore the use of sensors sensitive to the fluid pressure is desired. Also, the combination of the 3-component sensors with fluid-pressure sensors allows better wavefield decomposition so has advantages from an interpretation point of view. Currently, work is under way to exploit such a combination.

Next, a choice needed to be made with the type of sensor and its working range:

- They need to be able to work in the range of 1-100 Hz;
- They need to be able to have good sensitivity for passive and active data;
- Although not a requirement, but a preference: because of power requirements would be for passive elements rather than active elements

Based on these considerations, 3-C geophones do very well since they can be used in the range of 1-100 Hz although at the low frequencies they lose some dynamic range (12 dB/octave below resonance), have shown to be very good sensitivity for active seismic and good sensitivity for passive seismic, and are passive elements. For the fluid-pressure, passive transformer-coupled hydrophones were chosen since they work also in the range 1-100 Hz with a bit of loss at low frequencies (6 dB/octave below resonance), have very good sensitivity for active seismic and good sensitivity for passive seismic, and are passive elements.

One of the options was to bury sensors rather than placing at the surface. Especially fluid-pressure measurements in water can only be done at depth and not at the surface. In the testing at Exloo (and also at Annerveen, see Drijkoningen [3]), it turned out that burying the sensor at depth makes the signal levels of undesired surface waves become (much) lower than at the surface. This means that the sensor need to be buried which meant under the water table. To this aim, a special housing needed to be designed.

Because of the combination of two types of sensors and its use under the water table at depth, a special housing needed to be designed: it is desired to deploy as much at the same location as possible. At sea, such a combination is used on the sea floor, but in LOFAR it needs to be used in a borehole. In order to make sure the horizontal components of the geophone are well oriented, a special holder is designed which makes sure they are well oriented. A drawing is given in appendix C.3. Then this holder is used within a housing that can be used in an environmentally hostile area. A drawing/picture is given in appendix C.4. Finally, special casting material is used to permanently stick the two parts together. The specifications of the casting material are given in appendix C.5. So the 4C seismic sensors are especially designed for its use in LOFAR. The 4C sensors are placed at the field of Annerveen.

On the other fields, 3C geophones are used. On those fields, 7 sensors are placed; 4 at different depths in a borehole, and 3 in three other boreholes, 1 sensor in each borehole.

3.3 Local software components

Locally on a sensor field, the different software systems that are running are:
- Local Control System
- Local Data System
- Local Meta-data System

Local Control System (LCS)

Each site has it own Local Control System (LCS). By means of the LCS the geophones at the site can be configured and monitored. The Local Seismic Controller presented in the hardware description performs all the functions of the LCS. It controls the AD converters and the transport of data and meta-data over the LOFAR network. It communicates with the local LOFAR server on each field, which in turn communicates with the servers at Groningen, with the Blue Gene Stella.

Also in the hardware description, the AD controller was shown. This controller is supplied by the vendor, in this case Geometrics. The AD controller controls the AD converters and makes sure the data is properly handled. A specific task of the AD controller is to use a GPS clock to time-synchronize all AD converters on a common time-base.

A web application is installed for control and configuration of the seismic data acquisition process. With this web application the user can:

- Enter structural information of the site such as the number of devices in the site and their IP-address;
- Enter operational settings that are used during the acquisition such as the sample rate;
- Start and stop the acquisition process, if needed. Normal mode is continuously recording, but stopping the process may be needed for maintenance.

In appendix G an overview of the web application is given, using screenshots.

Finally, testing software runs locally. This software is supplied by the vendor, i.e., Geometrics. This software has the capability to test the hardware, i.e., the AD converters themselves. It tests the DC-offset, noise, gain accuracy, cross feed, harmonic distortion, filters, etc. This software is only available for Windows XP. It is not covered in the developed TNO LDS software because it is very specific.

To avoid placing too many servers in each field for maintaining and collecting data there is chosen for a virtualization option on this server. This makes it possible to create multiple virtual operating systems on a server and makes it very useful for using the testing and calibration software from Geometrics.

Local Data System (LDS)

Each field has it own data collection server that polls the sensors in the field and creates files of a predefined time interval. These servers are placed in the field nearby the sensors that means that they are spread over a wide area. By choosing for Linux as the underlying operating system the robustness and accessibility will be covered.

The Local Data System buffers the data from the AD converters temporarily before they are transported to the Central Data Storage system, the Blue Gene. The size of the disks is at this moment 500 GBytes. But this can be smaller depending on the reliability of the network or on the fact that there is no limitation on time/bandwidth for transport of large amounts of buffered data.

On each field data collection server there is an image service that creates real-time an image of the data. A webserver can make a request to the field gateway for this real-time image initiated by a user request from for example the geolofar website.

Local Meta-data System (LMS)

At every LOFAR field, meta-data about the local (specific) AD-converter configuration can be entered and queried from the internet by means of the Local Meta-data System (LMS). The LMS also provides meta-information to other local systems like LDS and LCS in a standardized and consistent way.

3.4 Power consumption

In this section a summary of the power consumption for the two configurations is given. For one field of the province-scale network:

Component	**Power breakdown (Watt)**
PC (low-power)	10
IP switch	80
AD converters (24)	15
DC Power Supply	10
6 4C sensors	-
Cables	-
Total	**115**

For the km-scale network (Annerveen), more PC's and AD converters are used:

Component	**Power breakdown (Watt)**
PC's (8, low-power)	80
IP switch	80
AD converters (504)	300
DC Power Supplies (8)	80
126 4C sensors	-
126 hydrophones	-
Cables	-
Total	**540**

4 Central LOFAR network

In this section, the bandwidth that is needed for the transportation over the LOFAR network is specified. To this end, a separation is made between two types of measurements:

- time-lapse seismic measurements, requiring higher bandwidths temporarily, and
- continuous monitoring for seismic interferometry and making use of events.

For the time-lapse seismic measurements it is assumed active seismic sources are used (think about vibratory sources or dynamite), and only the km-scale network will be used for this purpose. With such sources some control exists over the frequencies, so this allows higher resolution (band extends to higher frequencies). Also, time-lapse changes are generally subtle and small and do require higher resolution than the other passive recordings. 4C sensors are used, namely the 126 4-component ones (3-component geophone + hydrophone). Each component is one channel for the AD converter, so the km-scale network comprises totally 504 channels. For time-lapse seismic, frequencies up to 500 Hz are needed. So this will require higher sampling rates, namely a sampling of 2000 Hz (= 0.5 ms). As common in seismic data-acquisition systems, the AD converters contain proper anti-alias filters. For such a sampling frequency we obtain the data rate:

- 4.0 MBytes/sec (= 504 (channels)* 2000 (samples/sec) * 4 bytes/sample)

For the continuous monitoring with the province-scale network, 17 fields are equipped, each containing 7 3-component sensors. One acquisition system at a field comprises 24 AD converters. For the continuous monitoring, the maximum frequency of interest is defined as 100 Hz. Since this requirement is lower than for the time-lapse measurements, the choice of 2000 Hz is kept for sampling frequency in order to be consistent with the time-lapse measurements. For such a sampling frequency we obtain the data rate:

- For one LOFAR site (province-scale network): 192 KBytes per second (= 24 signals/acquisition-system * 2000 samples/sec * 4 bytes/sample)
- For all LOFAR sites of the province-scale network: 3.26 MBytes/sec (= 17 fields * 192 KBytes/field).

5 Central System (Rekencentrum Groningen)

The central system where all data from all sensor fields come together is at the Rekencentrum at Groningen. At Groningen, TNO has installed its own servers with separate LINUX-based machines. An overview of the different components is given in Figure 5.1.

At Groningen the following software systems will run:

- Central Data Storage (TNO system)
- Central Processing System (TNO system and Blue Gene)

Below, each of these systems is described:

Central Data Storage (CDS)

The Central Data Storage system (CDS) is responsible for storing temporarily the data from the LOFAR sites, so that it can be transported to other systems for further processing like the CPS or the permanent storage.

On the central system a Data Collection Server will run. This server hosts the two above systems. It retrieves the data from all the fields by making a connection to each field. The collected data is time stamped and registered in a local database. All the data files are stored on the Data Collection Server that acts as a disk manager that stores the data depending on the available storage space. A quota management on the server restricts the life time of each file before it will be overwritten by a new file.

There are two types of fields: there is one local/km-scale network planned with 96 x 4 component sensors and 96 1-component sensors, resulting in 480 channels on this field. The second type is the province-scale geometry with 45 fields that have 6 4-component sensors, resulting in 24 channels per site. Different scenarios for the temporary data storage can be worked out; these are shown in appendix F. The scenario anticipated and taken as reference is shown in the table below.

Temporary data storage on the CDS system

# channels	#Bytes/sample	#Samples/sec	Mbytes/sec	GBytes/day
45*24=1080 (province-scale network)	4	2000	8.64	746
480 (local/km-scale)	4	2000	3.84	332
Total			12.48	1078

To store all the data of all the fields for 14 days a storage capacity of 15 TByte is needed.

At this moment 14 TBytes of storage is available. It is used for storage of the retrieved data for processing and, secondly, it is used for storing the requested data for transport and permanent storage at TNO.

In order to guarantee the up time of the servers and specially the Central Data Server a failover and recovery strategy is implemented. See Appendix I: Failover and Recovery for details.

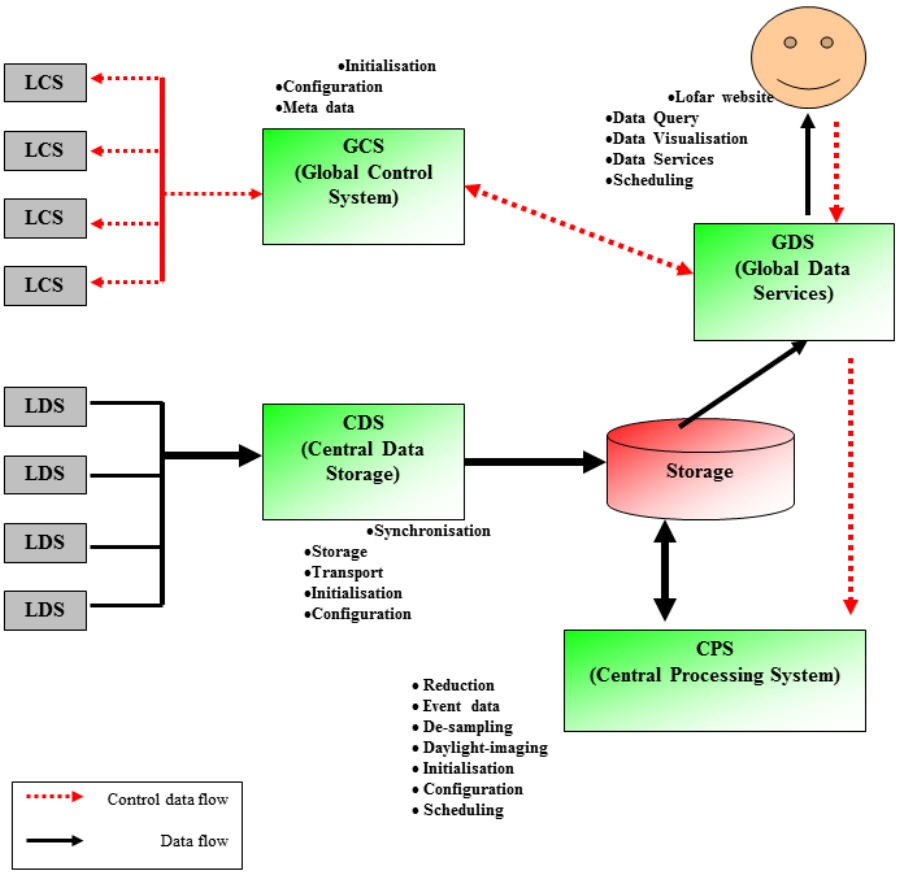


Figure 5.1. Pictorial overview of the different components, centralized at Groningen.

Central Processing System (CPS)

This system is responsible for processing the collected data from the sites. The following processes on this system can currently be identified.

- Data reduction/Seismic Interferometry
- Event detection

Currently, no more processing steps are taken into account. However, because of the very little experience in interferometry, it might be needed, in future, to add extra processing steps to make the results better.

Data reduction

One of the steps that need to be taken is data reduction since storing all data over all times is not feasible. Two approaches can be taken, one via compression techniques, and the other via the step inherent in seismic Interferometry, namely correlations of the data themselves. After correlation, the output is only a limited time-window (some 30 seconds) and only this time-window needs to be saved. Since in the LOFAR project the seismic-interferometric technique plays a central role, there is chosen for doing the data reduction by correlation only.

During the data reduction process there must be searched for a correlation of the recordings from the field sites. As an example 24 channels (6 sensors with 4 components per sensor) with 30 seconds of data at 500 Hz will result in $3.61.10^5$ measurements. By correlation this means 2 $N^{*2}\text{Log}(2\ N) + N = 1.4\ .\ 10^7$ calculations. If 1 calculation is 20 Flops, this results in 0.29 GFlops. For the province-scale geometry, correlation of 17 LOFAR sites (408 channels) will result in 4.9 GFlops, while for the km-scale geometry (504 channels) 6.0 GFlops will be needed.

[Also, for the correlation we correlate: P - P, V_x - V_x, V_y - V_y, V_z - V_z, V_x - V_y, V_x - V_z, and V_y - V_z, where P is the measurement from a hydrophone and V_i a component from the geophone. This means that for each position 10 correlations are necessary.]

Event Detection

The data that is collected on the Central Data Storage can be provided to the CPS as a stream. In order to detect real events on this stream, existing software of the KNMI will be used. The solution taken is to down-sample the data and send the data over to the KNMI. There the data will be analysed for events and separate events will be stored.

6 Data storage and retrieval sites (TNO, KNMI)

The data are only temporarily stored on a storage server at the Rekencentrum Groningen. The ultimate storage will take place at TNO and the KNMI. On the system of TNO, the following software systems will run:

- Global Data services System
- Global Control System
- Global Meta-data System

Global Data services System (GDS)

After processing the data on the Central Processing System the identified events can be stored permanently. The Global Data services System takes care of the permanent storage and all the retrieval functionality that allows for future processing of the data by retrieving parties.

The standard LOFAR products are two-fold. First, seismic events will be detected and stored, where events are mainly the gas-induced earthquakes. Second, continuous data will be stored but then in a compressed way using cross-correlations type compression as used in seismic interferometric techniques. How well this last technique will perform for seismic purposes is an important issue within the LOFAR project.

In the case of events, the data volume for storage is pretty restricted. Assuming 50 events per year and 10 minutes of data around an event, the data volume is in the order of 240 GBytes per year. (50 (events) * 10 (min/event) * 60 (sec/min) * 2000 (samples/sec) * 4 (bytes/sample)* 1080 (channels) = 260 GBytes.)

[Numbers for interferometry also in previous sections ??]

Global Control System (GCS)

In order to monitor and control the entire LOFAR network there is one global system. A web application exists to control and configure the LOFAR-wide data acquisition process. With this web application the user can

- enter operational settings that are used during the acquisition such as the sample rate
- start and stop the acquisition process

Global Meta-data System (GMS)

The complete Geo-LOFAR network with its configurations can be queried from the internet by means of Global Meta-data System. This system can be used by other Global systems like GDS and GCS to get consistent meta-information quickly.

7 Data access for users (e.g., TU Delft)

This section describes the data access from remote sites.

Since a lot of seismic data is constantly measured and stored by the LOFAR-network and because many data consumers want to use these data again at any arbitrary moment in time, a graphical tool has been developed that allows the user to get easily certain selections of measured seismic data for further processing at the user's own local site.

The tool that has been developed for the purpose of getting data from the LOFAR-network is the GeoLOFAR-web site. The URL of the web site is: http://geolofar.nitg.tno.nl.
In Figure 7.1 the home page is given:

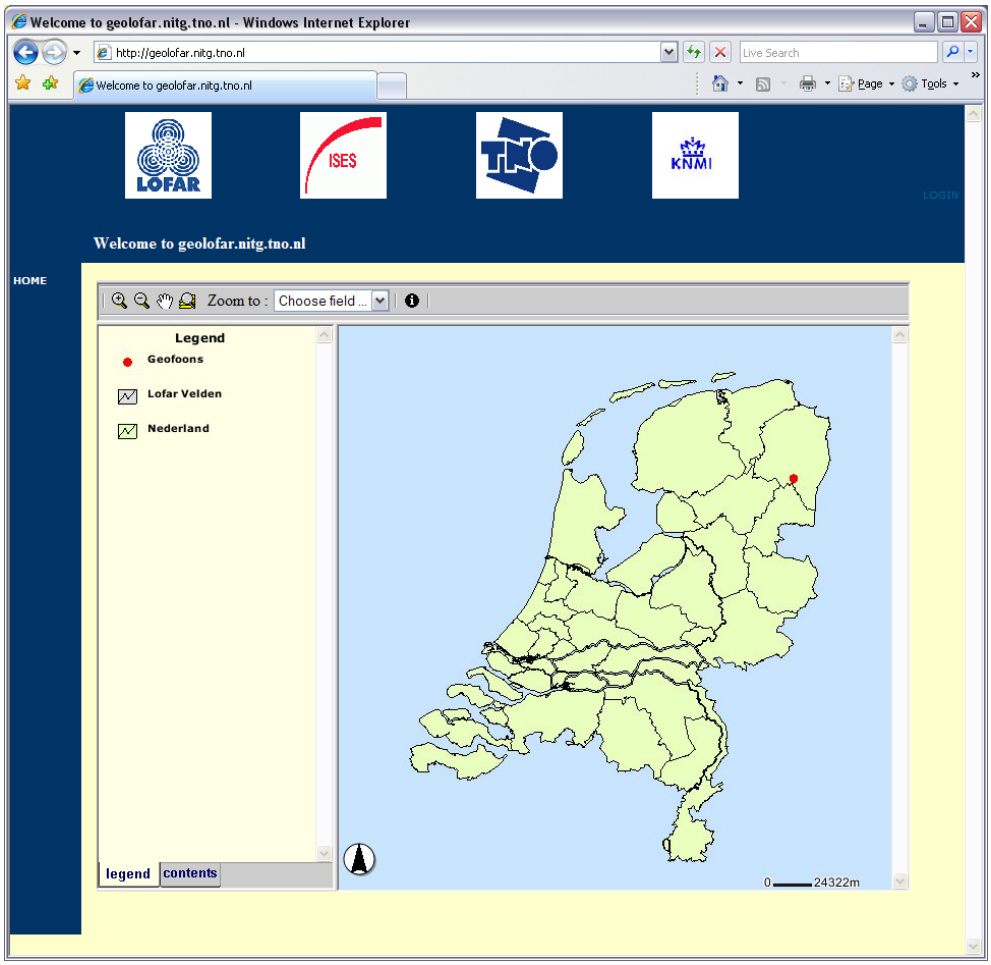


Figure 7.1 Home of website Geolofar.nitg.tno.nl

The website has 3 functions:

- *Data-function*: this function allows browsing through all stored data files. Millions of different data files are stored separately per field and per day.
- *View-function*: the view function gives us a graphical overview of all recently measured data. The overview appears in a popup window and is being refreshed automatically every six seconds. In the overview all measurements of all available data channels are taken into account;

- *Query data-function*: the query data function helps us to find data files of a certain period in time. We have the possibility to formulate two types of queries:
    - All data files around a certain event in time or
    - All data files with a certain time interval.

For the use of the website, the reader is referred to appendix H.

8 References

[1] Drijkoningen, G.G. et al., 2007. Project Plan of the Seismic Applications in LOFAR. Report GeoLOFAR-002.

[2] Drijkoningen, 2007. Design of Seismic network in LOFAR: Testing at Exloo test-site. Report GeoLOFAR-006

[3] Drijkoningen, G.G., J. Brouwer and H. Haak, 2003. Veldtest Meetnet nabij Annerveen, 2003: Metingen, Resultaten en Implicaties, pp.24. (in Dutch)

Appendix A: AD converters: The “GeoEel”

GeoEel:
This system is the system supplied by the vendor Geometrics Inc. It is an off-the-shelf system which is designed for seismic monitoring and not specifically for GeoLOFAR. It contains digitizers, DC/DC power supplies, timing control mechanisms and output over Ethernet lines. It is designed as a field-deployed distributed system. As such it has internal power supplies and processors, and is packaged in a rugged housing, if needed. It is designed to store and forward Ethernet packets, daisy-chain fashion, along a continuous cable to identical systems further from the host computer and human operator. The GeoEel speaks standard TCP/IP, and it is easy to communicate with using sockets, HTPTP or telnet.

Specifications:

	GeoEel	**Units**
Max Sampling Rate	2	kHz
High-frequency Cut-off	7	kHz
Low-frequency Cut-off	≈ 1	Hz
Available Gains	1, 2, 8, 32, 128	Voltage Ratio
Signal Input Voltage	+/- 2.25	V p-p differential
Distortion	0.0003 @ 2ms x 32 gain	%
Noise	0.20 @ 2ms x 32 gain	µV RMS
CMR	> 100	dB
Dynamic Range	110 @ 2ms, x 32 gain	dB
Ethernet Link	100 Base-T	From digital board
Power Consumption	5W	Per 8-channel module

Instrument constant
1.1809610^{-5} mV per LSB at 30dB gain

Input impedance
An equivalent circuitry describing the input impedance of the system is given in Figure A.1:

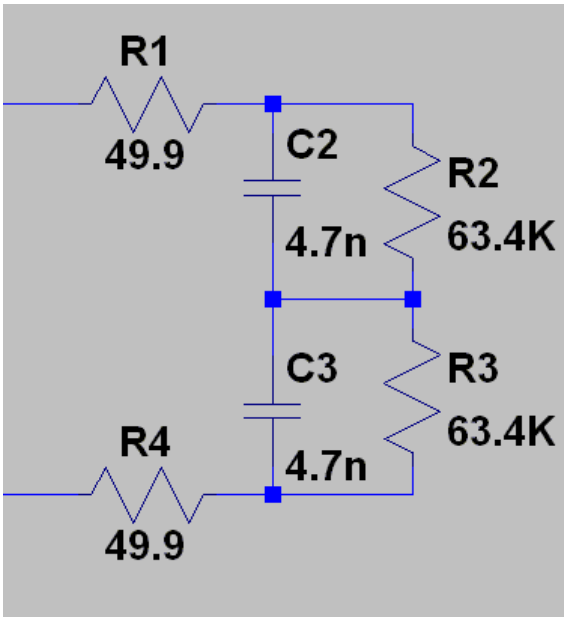


Figure A.1. Equivalent circuitry for input impedance of the GeoEel.

Hardware Description

The GeoEel system consists of 3 boards in a set, 8 channels per set. The GeoEel consists of the analogue board, the DSP board, and the Ethernet board.

Analogue board:
- Calibration and reference DAC
- ADC converters, with integrated programmable gain pre-amplifiers
- Output: serial data stream, each channel read through a MUX
- Required input: many registers to be written to set up clock, sample rates, gains, inputs and so on.

DSP board
- DSP device
- 5Vpower supply
- Flash memory and clock circuitry
- Memory for recorded data
- Output: parallel data stream of buffered, de-multiplexed data
- Input: Commands from the user to determine system parameters. System may store these in flash memory, to be automatically loaded on power up.

Ethernet board
- Coldfire embedded processor, running embedded Linux operating system
- Three port Ethernet switch
- 48V input, 3.3V output power supply
- Output: TCP/IP socket communication, HTML, telnet.
- Input: user commands setting gains, sample rates, record length, etc.

Firmware:
Function of DSP

The DSP controls the setup of the ADC chips, setting internal; parameters such as gain setting and sampling rate. It could perform filtering of the data if desired. It gathers samples from the ADCs and stores them into shot records in memory.

Function of Coldfire

The Coldfire processor serves as the main interface to the outside world. It runs an embedded Linux operating system, and is thus capable of working at high-level interfaces with the outside world, including HTTP, telnet, and sockets. It receives commands from the host computer, and translates them for the DSP. It also sends recorded data out to the Ethernet switch.

Function of Ethernet switch

The Ethernet switch is used primarily to increase the distance between 8-channel modules to the full 100m Ethernet specification. Data from other GeoEels passes through this switch, and data from itself is sent out the switch to the host computer. TCP/IP is the protocol used in communicating throughout the system.

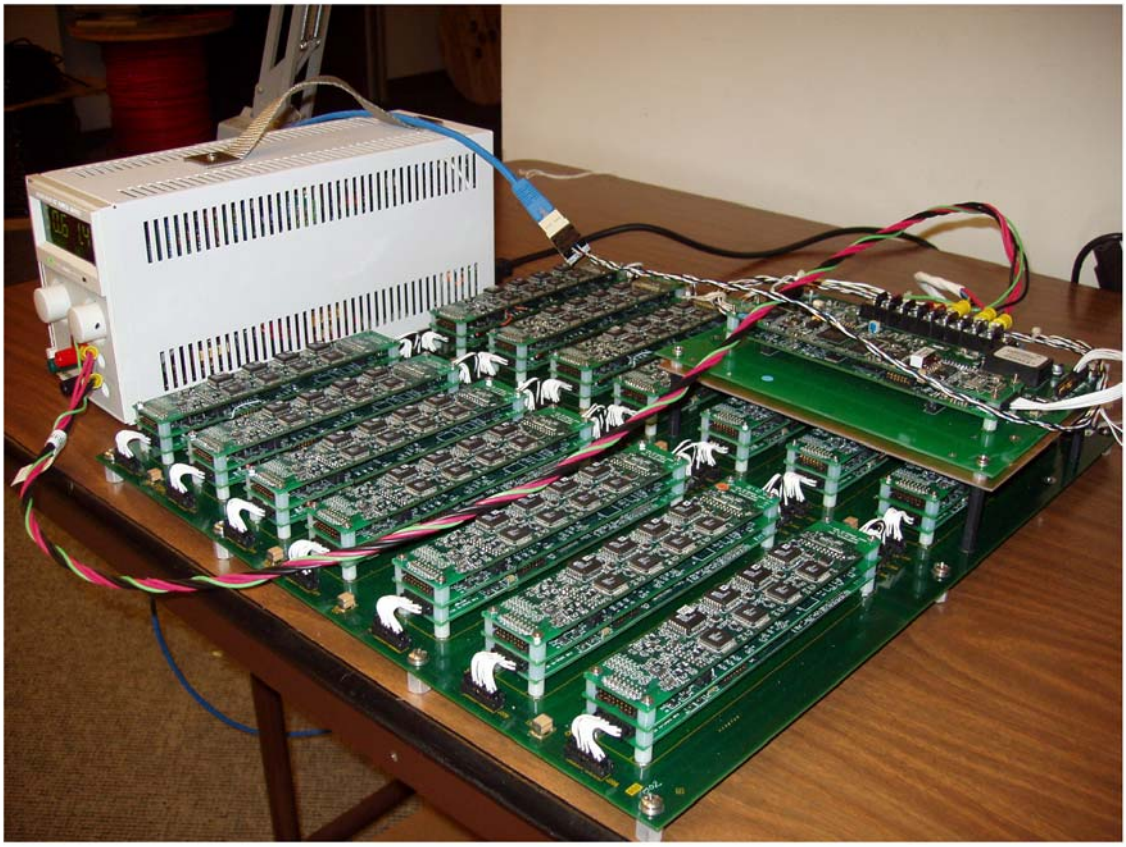


Figure A.2. Photo of GeoEel-boards, with 14 8-channel boards. (On the left (white): 48V power supply).

Appendix B: 220V AC to 48V DC converter

The Xantrex HPD Series stands for "High Power Density", providing 300W in a quarter-rack wide chassis. The HPD uses switch-mode technology combined with linear post regulation to provide performance comparable to an all-linear design.
(Webpage: http://www.xantrex.com/web/id/84/p/1/pt/27/product.asp)

Model: HPD 60-5 M2, with locking knob M13.

Electric Specifications:

Output Ratings	
Output Voltage	0-60V
Output Current	0-5A
Output Power	300W
Line/Load Regulation	
Voltage (0.01% of Vmax + 2mV)	8mV
Current (0.01% of Imax + 1mA)	1.5mA
Meter Accuracy	
Voltage (1% of Vmax + 1 count)	0.7V
Current (1% of Imax + 1 count)	0.06A
Output Noise & Ripple	
rms	5mV
p-p (0-20MHz)	100mV
Drift (8 hours)	
Voltage (0.02% of Vmax)	12mV
Current (0.03% of Imax)	1.5mA
Temperature Coefficient	
Voltage (0.015% of Vmax/^{o} C)	9mV
Current (0.02% of Imax/^{o} C)	1mA

General Specifications:

Operational AC Input Voltage	200-250 VAC (50/60 Hz)
Switching Frequency	Nominal 100 kHz
Voltage Mode Transient Response Time	< 500 μs recovery to 50 mV band for ±50% load change in range of 25% to 100% of rated load
Operating Ambient Temperature	0 to 30^{o} C for full rated output. Above 30^{o} C, derate output linearly to zero at 70^{o} C.
Storage Temperature Range	-55^{o} to +85^{o} C
Humidity Range	0 to 80% RH, non-condensing
Front Panel Voltage and Current Control	10-turn voltage and 1-turn current potentiometers
Front Panel Voltage Control Resolution	0.02% of maximum voltage
AC Input Connector Type	IEC 320 connector
Weight	Approximately 3.5 kg
Approvals	CE-marked units meet standard: EN55011 (Group 1 Class A),

	En500781-2, EN50082-1 and IEC 1010-1, NRTL/C, CSA certified

Analog Programming:

Remote On/Off and Interlock	2-25V signal or TTL-compatible input, selectable logic
Remote Monitoring	0-10VDC for 0-100% or rated vo9ltage or current ±1.0%
Over Voltage Protection Trip Range	3V to full output + 10%
Tracking Accuracy	±1% for series operation

Figure B.2 Photo of converter of 220V AC to 48V DC.

Appendix C: Sensors and housing

C.1. Geophone: SM-6 geophone from Sensor b.v.

Specifications

SM-6/U-B 4.5Hz 375 Ω (B-coil)

Frequency	
Natural Frequency f_n	4.5 Hz
Tolerance	±0.5 Hz
Maximum tilt angle for specified f_n	0^o
Typical Spurious Frequency	140 Hz
Distortion	
Distortion with 0.7 ips p.p. coil-to-case velocity	< 0.3%
Distortion measurement frequency	12 Hz
Maximum tilt angle for distortion specification	0^o C
Damping	
Open-circuit damping	0.56
Open-circuit damping tolerance	±5 %
Resistance	
Standard Coil Resistance	375 Ω
Tolerance	±5 %
Sensitivity	
Open-circuit sensitivity	28.8 V/m/s
Tolerance	±5 %
RtBc f_n	6000 Ω Hz
Moving mass	11.1g
Maximum Coil Excursion p.p.	4 mm
Physical	
Diameter	25.4 mm
Height	36 mm
Weight	81g
Operating Temperature Range	-40^o C to $+100^o$ C

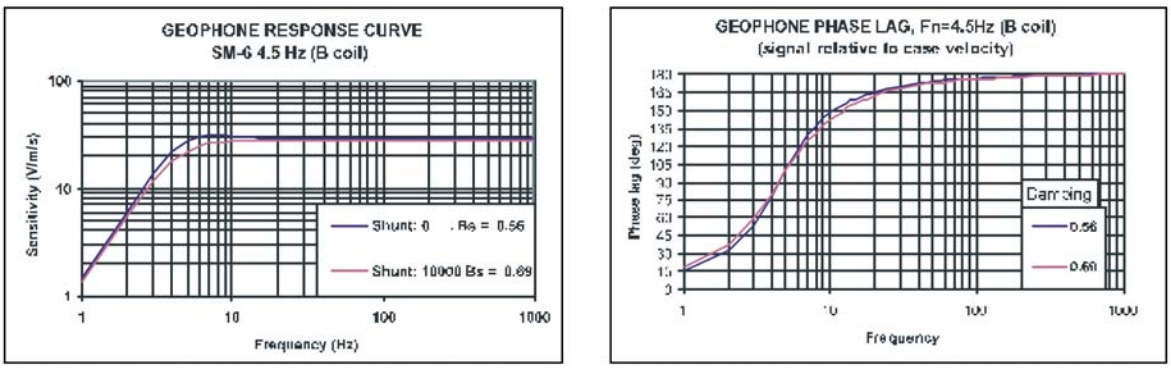


Figure C.1. Frequency response curves of Sensor SM-6 geophones

C.2. Hydrophone: Benthos PreSeis 2520

General Characteristics

Impedance	1730 Ω nominal at 100 Hz
DC resistance	350 Ω ± 5% at 20^{o} C
Sensitivity	-206.8 ± 1.5dB re 1V/µPa (4.58µV/µbar)
Change vs. frequency	Less than 3.0dB from 10Hz to 1000 Hz
Change vs. depth	Less than 1dB fro 0.3m to 200m
Change vs. temperature	Less than 1.5dB from 0^{o} to 50^{o} C
Natural frequency	10Hz ± 15 % at 5mV rms output
Distortion	(not specified)
Mechanical Resonance	Greater than 2.0 kHz
Leads	Two 16 AWGF stranded conductors, polypropylene insulation, polyurethane cable jacket
Polarity	A positive (increase in) acoustic pressure generates positive voltage on yellow conductor

Temperature

Operating	From 0^{o} to 50^{o} C
Storage	From -10^{o} to 55^{o} C

Depth

Maximum operating	200m
Maximum survival	275m

Physical

Length	208.7 mm with protective cover, without lead and connector
Diameter	61.7 mm
Weight	426 g without lead connector
Displacement	221.7 cm^3 without lead and connector

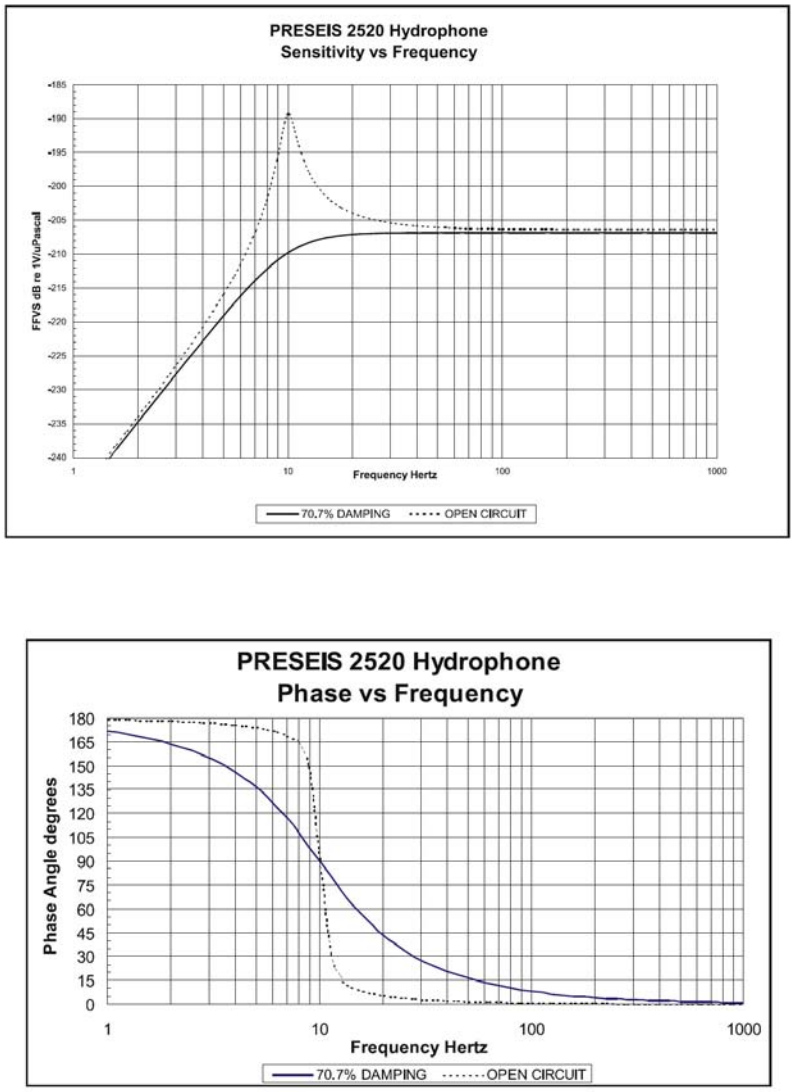


Figure C.2. Frequency response curves of PreSeis hydrophone

C.3. Holder

The 3C geophone is put in a special holder as shown in Figure C.3.

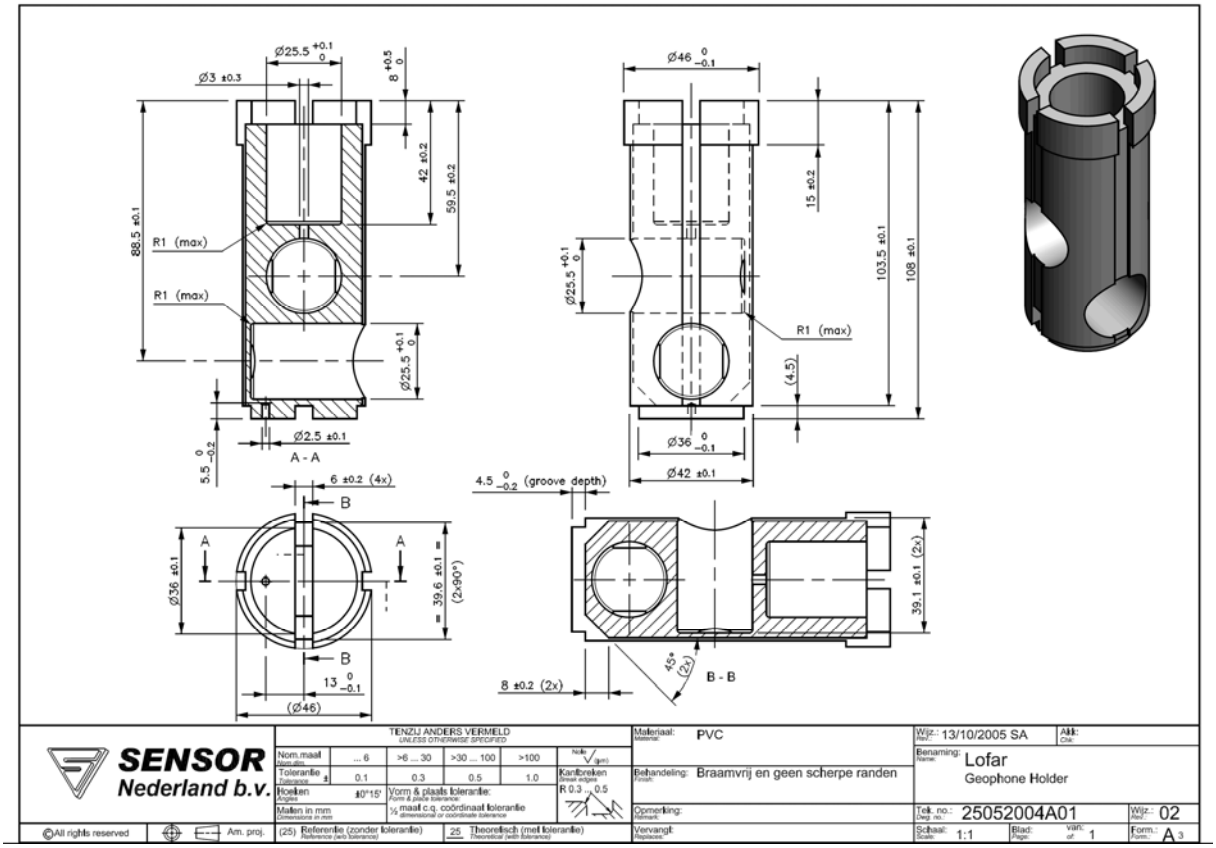


Figure C.3. Drawing of the holder for the 3 components of the SM-6 geophone.

Photo of holder of 3C geophone, with two components of the geophone partly shown.

C.4. Housing of 3C geophone and hydrophone.

In Figure C.4 the drawing of the 4C sensor (geophone + hydrophone) housing is shown.

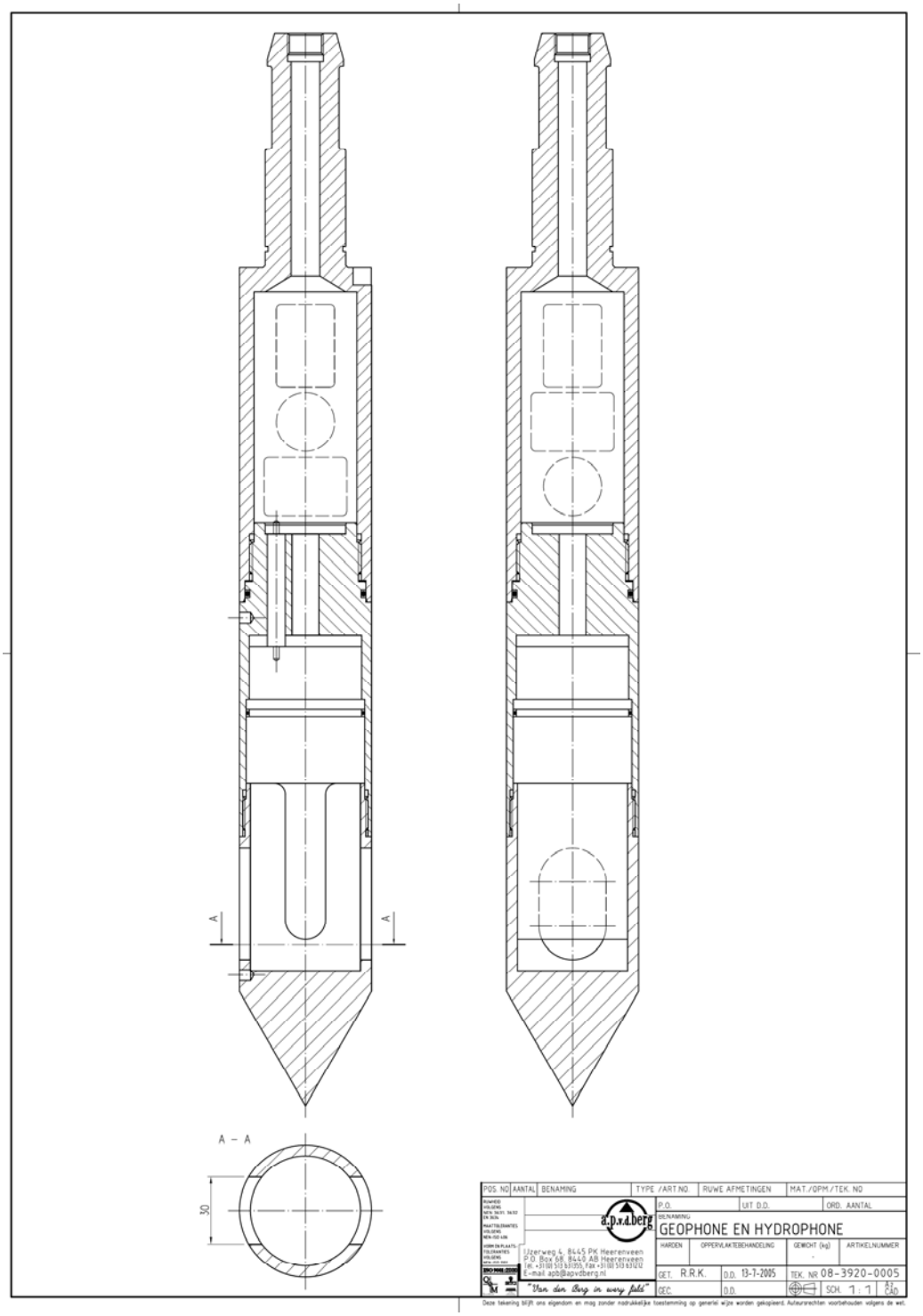


Figure C.4. Drawing of the housing for the 4C (geophone + hydrophone) sensor.

Figure C.5. Photo of housing of 4C sensor.

C.5. Casting material

As casting material for the housing, Scotch-cast® No.815 Resin is used. It is an unfilled solvent free two component Epoxy Resin for room temperature curing. It is one of a system of products available from 3M Electrical Specialties Division. This product has been used extensively for hydrophones deployed at sea.

Its features are:

- Good adhesion on metals and different plastics;
- Highly flexible;
- Low viscosity;
- Re-enterable.

Its specifications are given in the table below.

Property	*Value*	*Specification*
Density	1.14 g/cm^3	DIN 53479 / ISO 0061
Viscosity 23^o C	0.77 Pa	DIN 16945 / ISO 3104
Gel-time	30 min.	DIN 16945 procedure B
Shore-D-Hardness	At 55	DIN 53505 / ISO/R-868
Tensile Strength	1.0 N/mm^2	DIN 53455 / ISO/R527
Elongation at Break	33 %	DIN 53455 / ISO/R527
Glass Transition Temperature	– 2^o C	DIN 53445 / ISO/DR 533
Electrolytic Corrosion	AN 1.2	VDE 0303 / IEC 426
Dielectric Strength	24 kV/mm	VDE 0303 / IEC 243
Dissipation factor: At 23^o C, 50 Hz At 40^o C, 50 Hz At 60^o C, 50 Hz	 0.13 0.225 0.36	VDE 53479 / IEC 250
Dielectric Constant: At 23^o C, 50 Hz At 40^o C, 50 Hz At 60^o C, 50 Hz	 5.7 7.6 6.8	VDE 53479 / IEC 250
Track Resistance (low voltage)	CTI 600	DIN / IEC 112

Appendix D: Cables

The cables chosen needed to be waterproof for duration of 10 years. Poly-urethane (PUR) material is the material which is often used in the offshore industry so are well suited for land applications. The cable from Ehrbecker-Schiefelbusch was chosen: S 200 series. Its outstanding features are:

- labs uncritical (labs = enamel moisturing interfering substances)
- flexible at low temperatures
- halogen-free
- travel >10m is possible
- high abrasion resistance
- minimal bending radius
- small outer diameter

In the table below the properties are given

Properties	*Value/Specification*
Conductor	Bare copper strands acc. to IEC 60228, EN 60228, VDE 0295, class 6
Insulation	TPE 510
Colour code from 2 conductors	Black cores with consecutive numbers acc. to EN 50334; Green-yellow earth wire from 3 cores
Stranding	Specially adjusted layering with non-woven tape over each layer
Wrapping	Non-woven type
Sheath material	PUR, TMPU acc. to DIN VDE 0282 part 10 + HD 22.10 with mat surface
Nominal voltage	Uo/U 300/500 V
Testing Voltage	2000 V acc. to DIN VDE 0281 part 2 + HD 21.2
Minimal bending radius (continuously flexible)	5 x d
Radiation resistance	5 x 10^6 cJ/kg
Temperature range: Fixed laying: Flexible application:	 $-50^o/+90^o$ C $-40^o/+90^o$ C
Halogen-free	Acc. to DIN VDE 0472 part 815 + IEC 60754-1
Oil resistance	Very good – TMPU acc. to DIN VDE 0282 part 10 + HD 22.10
Chemical Resistance	Good against acids, alkalines, solvents, hydraulic liquids, etc.
Continuous Flexibility	Very good
Weather Resistance	Very good
Absence of harmful substances	Acc. to RoHS-guideline 2002/95/EG as well as GefStoffV appendix IV-no.24, see page N/14

Data cable characteristics:

- Special data cable LiY11Y, 4 x 2 x 0,25 mm^2
- PUR Data cable twisted-pair

- Characteristic acc. to DIN 47100
- Outer diameter: ± 6,4 mm
- Temperature range
    - Moved: $-5^{o}/+70^{o}$ C
    - Not moved: $-30^{o}/+70^{o}$ C
- Bending radius
    - Fixed laid: 5 x d
    - Freely moved: 10 x d

Appendix E: GPS antenna

GPS antenna, from D.D.S. Electronics.
(Webpage: http://www.d-d-s.nl/gps-antenne.htm)

Specifications

Size	48mm (width x 15 mm (height) x 58 mm (length)
Weight	65 grams
Cable Length	3 meter
Connector Type	BNC-M
Mounting	Magnet or screws 3 mm
Power	2.5 – 5.0 V DC
Current consumption	6 mA ± 15 %
Gain	± 27 dB

Figure E.1. Photo of GPS antenna

Appendix F: Different scenarios of data rates

In this appendix, different scenarios are worked out. For the continuous monitoring 2000 Hz is used.

Field type	# Fields	# sensors	# channels
1 Province-scale field	17	6 * 4 component	24
2D cross (km-scale)		126 * 4 comp.	504

Data transport 1 site of province-scale geometry

# channels	#Bytes	Sample rate (Hz)	MBytes/sec	GBytes/day
24	3	2000	0.14	11.59
24	4	2000	0.18	15.45

Data transport 17 sites of province-scale geometry

# channels	#Bytes	Sample rate (Hz)	Mbytes/sec	GBytes/day
408	3	2000	2.44	210
408	4	2000	3.26	282

Data transport km-scale geometry

#channels	#Bytes	Sample rate (Hz)	MBytes/sec	GBytes/day
504	3	2000	3.02	260.9
504	4	2000	4.03	348.2

Total Bandwidth and Storage capacity ordered by bytes per sample.

Field	Mbytes/sec	GBytes/day
17 province-scale fields at 3 Bytes per sample at 2000 Hz	2.44	210
1 2D Cross (km-scale) 3 Bytes per sample at 2000 Hz	3.02	261
Total	6.46	471

Field	Mbytes/sec	GBytes/day
17 province-scale fields at 4 Bytes per sample at 2000 Hz	3.26	282
1 2D Cross (km-scale) 4 Bytes per sample at 2000 Hz	4.03	348
Total	7.29	630

To store all the data of all the fields for 14 days the following storage capacity is needed:

Sample rate and Byte size	Storage Capacity (TBytes)
2000 Hz 3 Bytes	6.59
2000 Hz 4 Bytes	8.82

Appendix G: GeoLOFAR Seismic Control software

The following screenshots provide an overview of the web application.

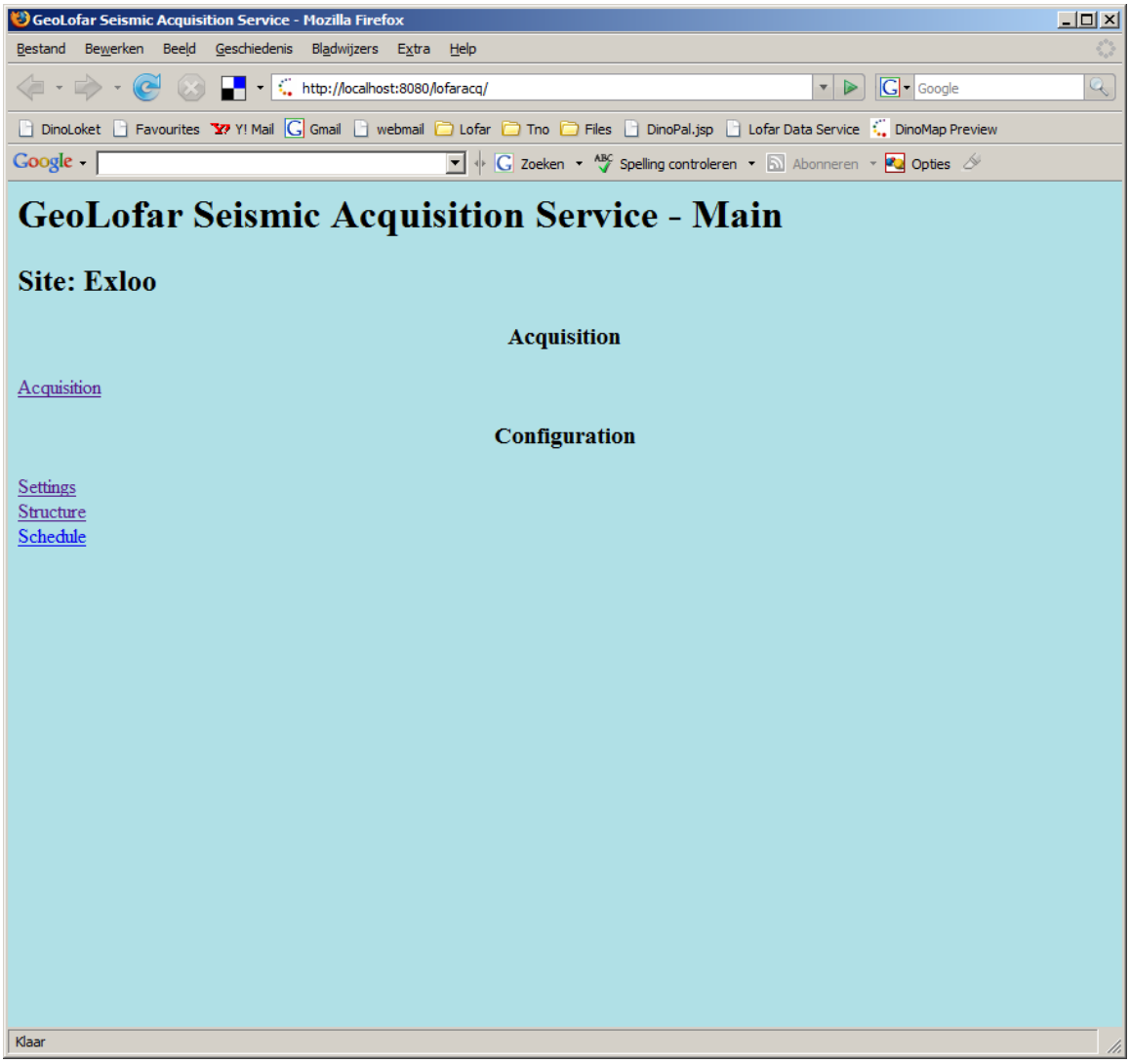


Figure 0.1 Main menu

This is the main menu for the web Application. From here the user can navigate to the different parts of the application.

Acquisition control

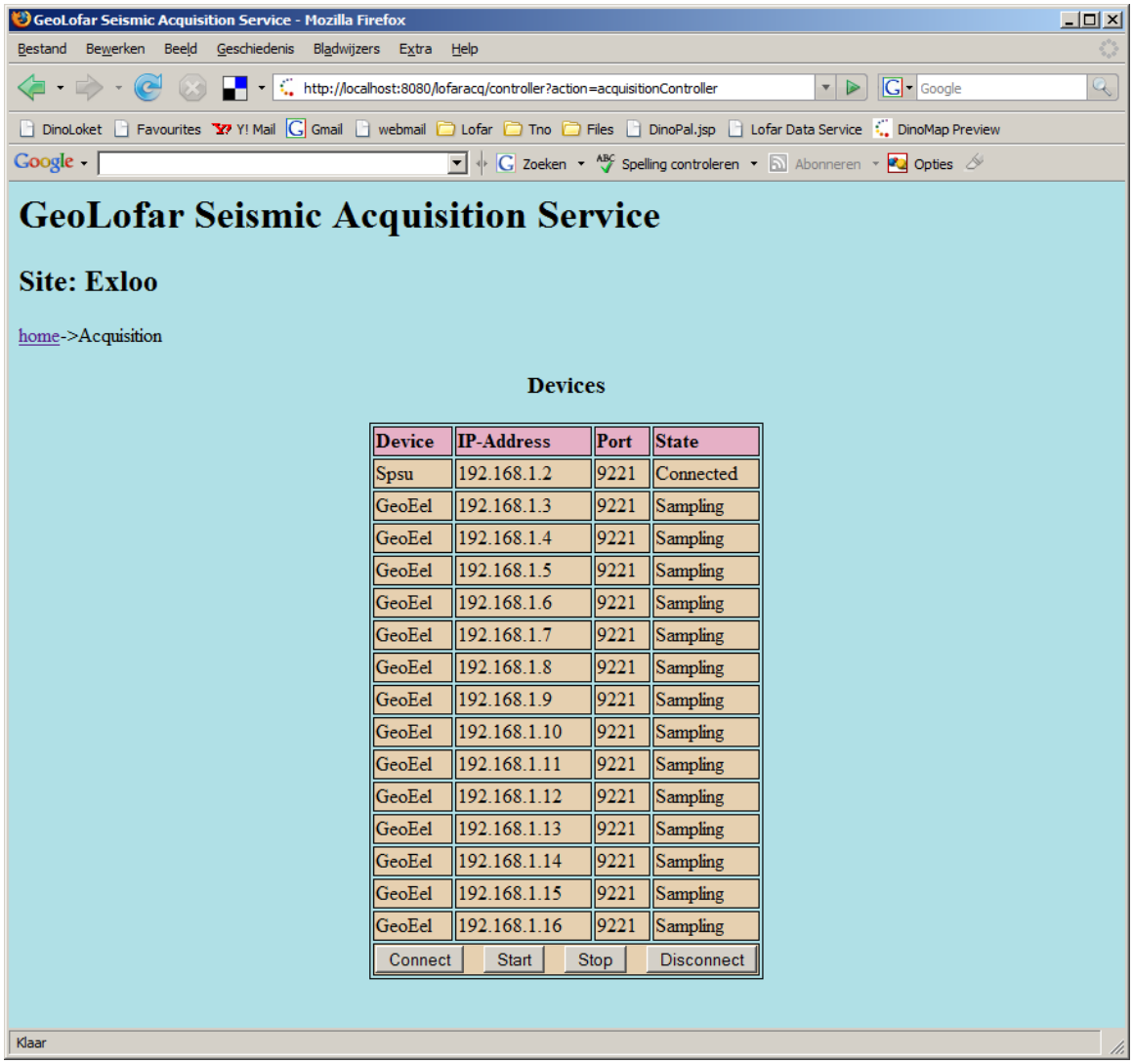


Figure 0.2 Acquisition control

In this screen an overview is presented of all the configured devices and their state.
There are buttons for

- Connect
  Establishes a socket connection to every device and activates the selector process that monitors the sockets for traffic and handles it.
- Start
  After the socket connections have been established the user can start the acquisition with this button. All the AD-converters are initialized and a start-trigger is sent to the AD-controller (SPSU) which in turn triggers all the AD-converters to start sampling simultaneously.
- Stop
  With this button the stop-trigger is sent to the AD-converters so that the sampling is ended.
- Disconnect
  Deactivates the selector process and closes all socket connections to the devices.

Operational settings

Through the next 3 screens the user can respectively change general settings, AD-controller (SPSU) settings and AD-converters settings.

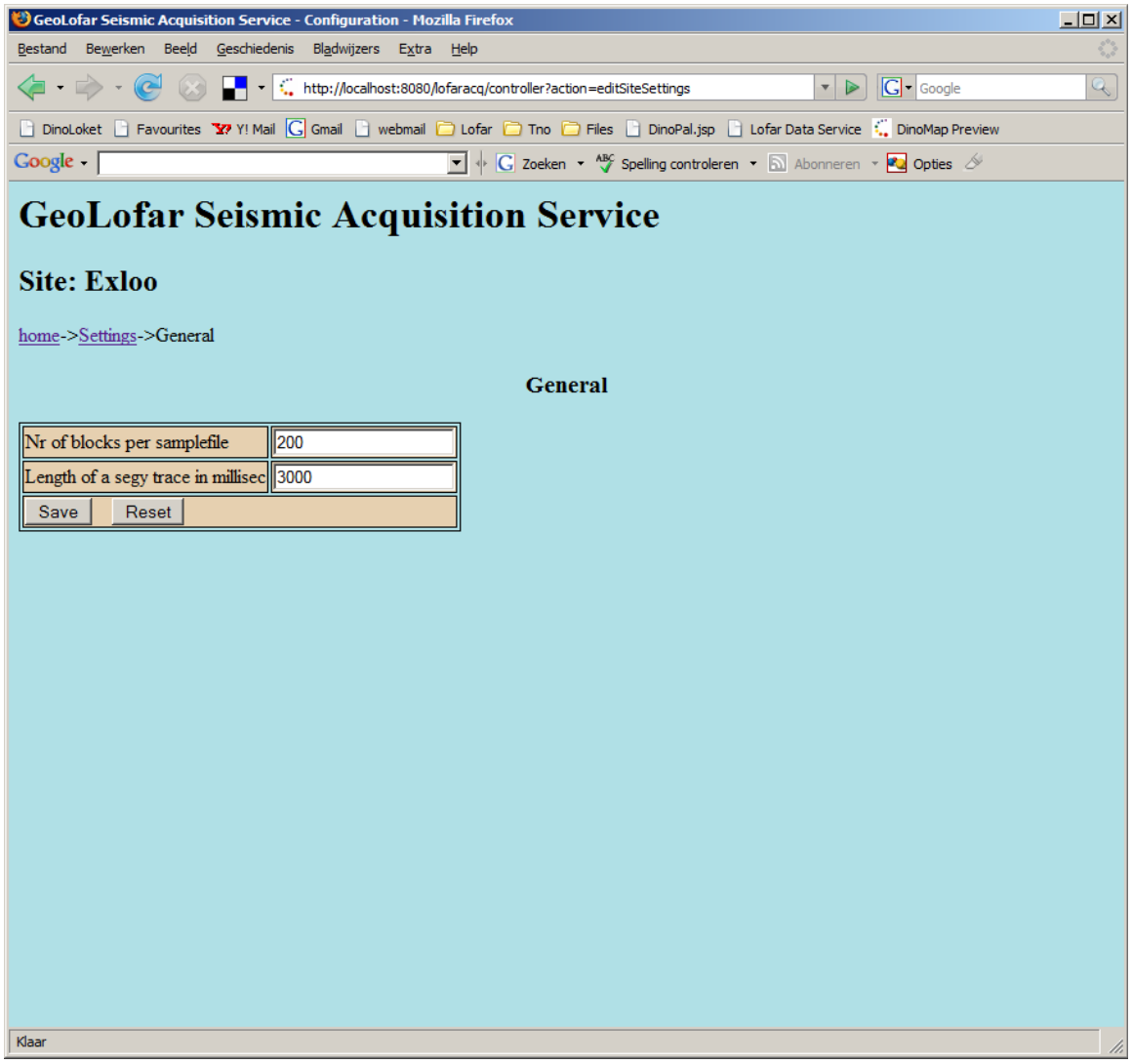


Figure 0.3 General settings

Nr of blocks per sample file: This is the number of sample blocks that are written to one sample file. When this number is reached the current sample file is closed and a new sample file is created.

Length of SEGY trace in millisecond: On every site a SEGY file is generated on the fly for monitoring purposes. This parameter sets the length of the traces generated in this SEGY file.

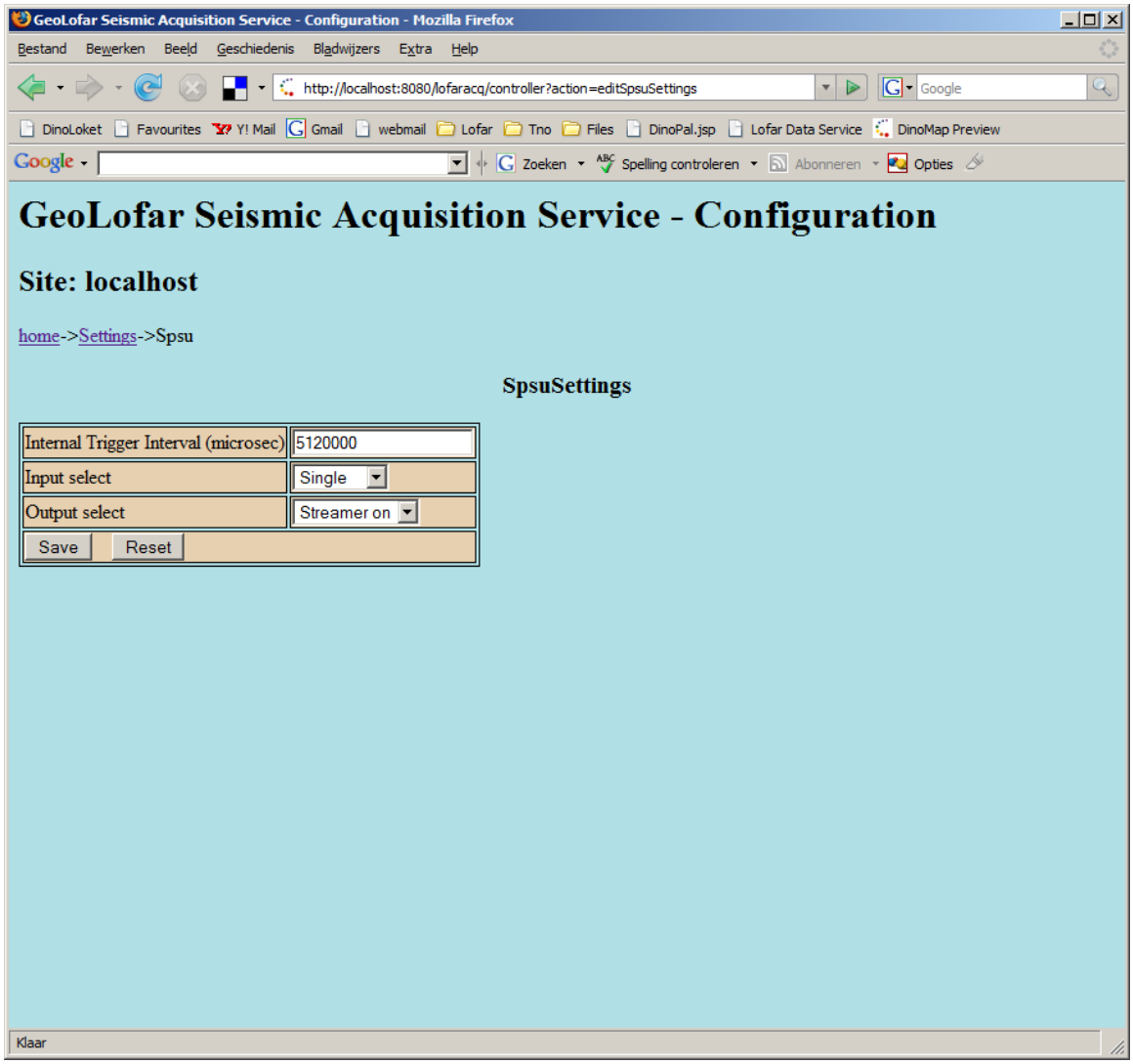


Figure 0.4 AD-controller settings

Internal trigger interval	Not applicable
Input select	Single
Output select	Streamer on

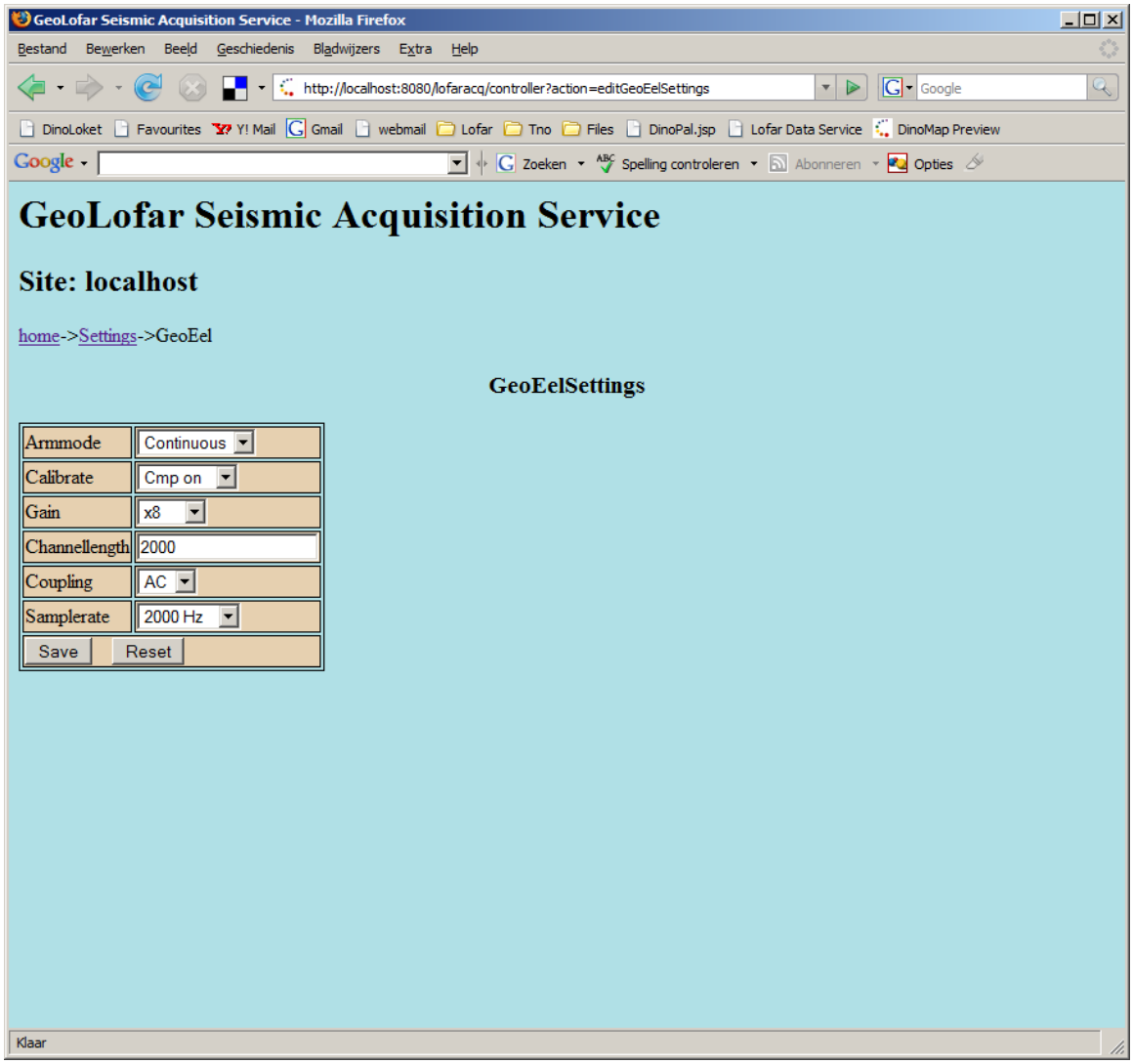


Figure 0.5 AD-converter settings

These settings apply to all the AD-converters of a site.

Arm mode	Continuous or Triggered
Calibrate	Not applicable
Gain	Gain factor
Channel length	Nr of samples per block of data received from the AD-converter
Coupling	Selects AC or DC coupling
Sample rate	Frequency with which samples are recorded. 2000Hz means that the device takes 2000 samples per second.

Structural information

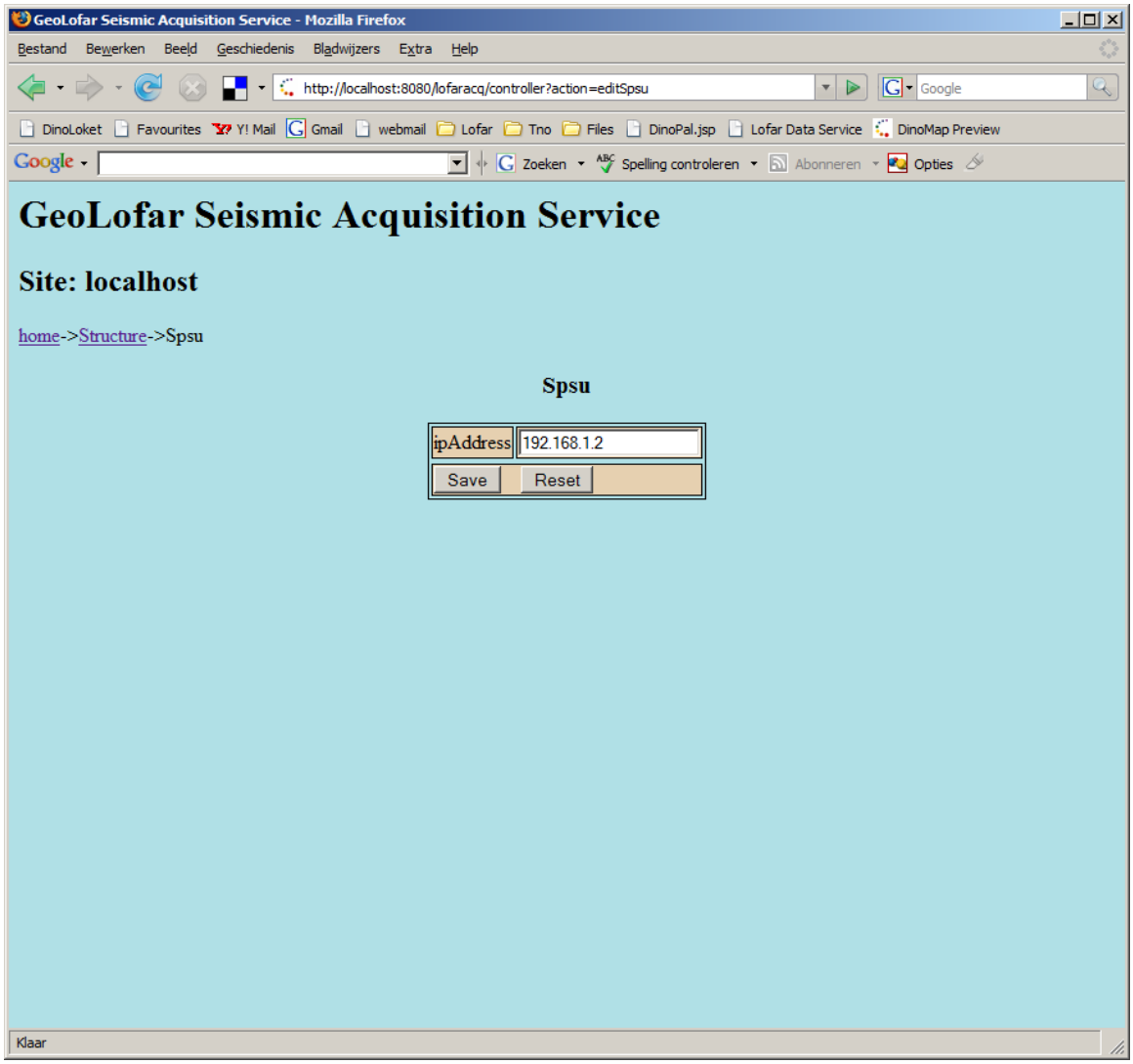


Figure 0.6 AD-controller structural information

IP Address	The IP address of the AD-controller device

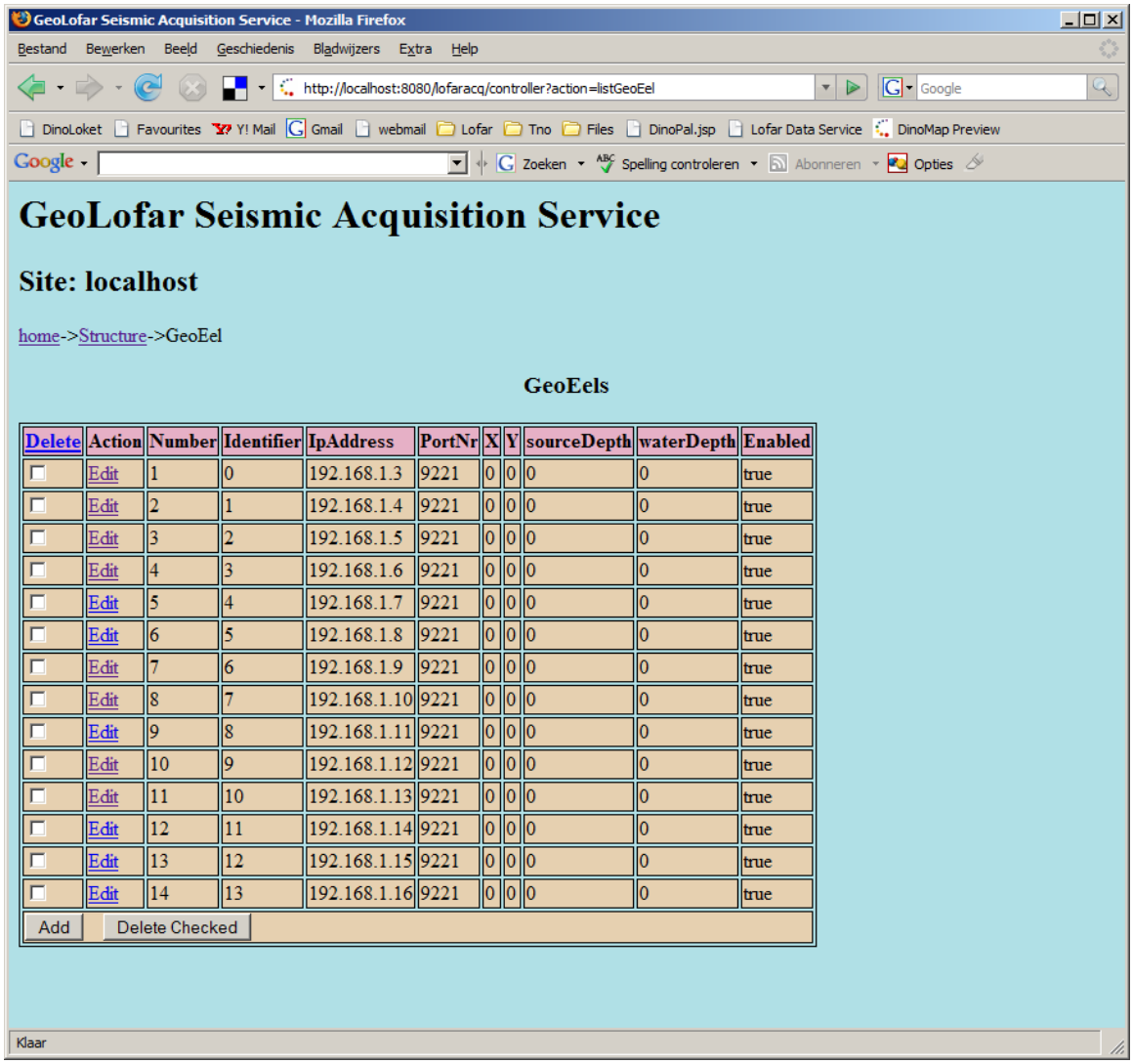

GeoLofar Seismic Acquisition Service - Mozilla Firefox
Bestand Bewerken Beeld Geschiedenis Bladwijzers Extra Help
http://localhost:8080/lofaracq/controller?action=listGeoEel
DinoLoket Favourites Y! Mail Gmail webmail Lofar Tno Files DinoPal.jsp Lofar Data Service DinoMap Preview
Zoeken Spelling controleren Abonneren Opties
GeoLofar Seismic Acquisition Service
Site: localhost
home->Structure->GeoEel
GeoEels
Delete Action Number Identifier IpAddress PortNr X Y sourceDepth waterDepth Enabled
Edit 1 0 192.168.1.3 9221 0 0 0 0 true
Edit 2 1 192.168.1.4 9221 0 0 0 0 true
Edit 3 2 192.168.1.5 9221 0 0 0 0 true
Edit 4 3 192.168.1.6 9221 0 0 0 0 true
Edit 5 4 192.168.1.7 9221 0 0 0 0 true
Edit 6 5 192.168.1.8 9221 0 0 0 0 true
Edit 7 6 192.168.1.9 9221 0 0 0 0 true
Edit 8 7 192.168.1.10 9221 0 0 0 0 true
Edit 9 8 192.168.1.11 9221 0 0 0 0 true
Edit 10 9 192.168.1.12 9221 0 0 0 0 true
Edit 11 10 192.168.1.13 9221 0 0 0 0 true
Edit 12 11 192.168.1.14 9221 0 0 0 0 true
Edit 13 12 192.168.1.15 9221 0 0 0 0 true
Edit 14 13 192.168.1.16 9221 0 0 0 0 true
Add
Delete Checked
Klaar

Figure 0.7 Overview of structural data for the AD-converters

Before an AD-converter can be used in the acquisition process on this site, its structural data has to be configured through this screen.
This screen provides an overview of all the AD-converters of the site. It offers the following possibilities

- Edit
  opens the edit screen where the different attributes of the structural data of the can be changed.
- Add
  opens the add screen for addition of a AD-converter
- Delete checked
  removes the structural data for the AD-converters that are selected in the list.

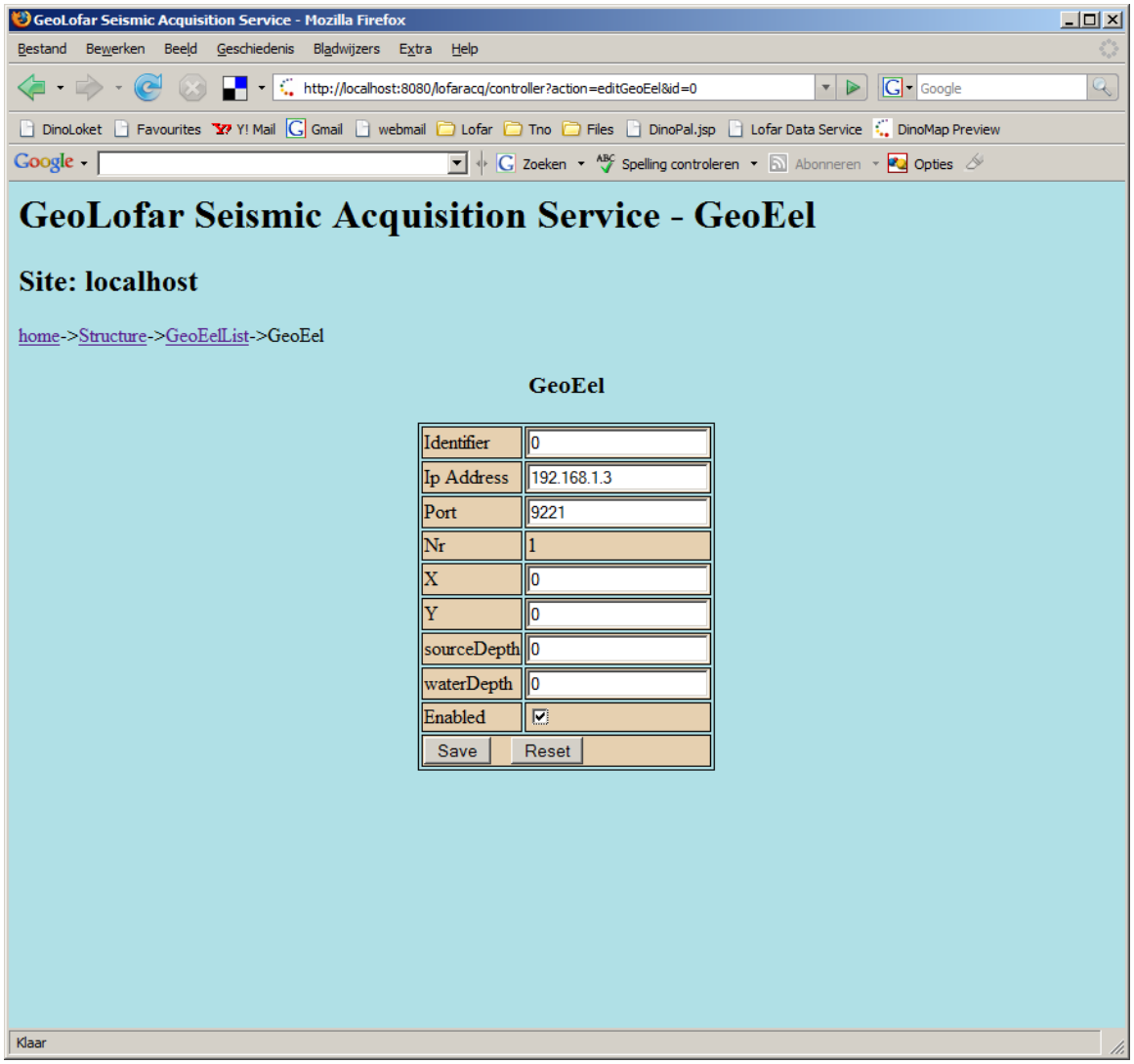


Figure 0.8 Structural data for a AD-converter

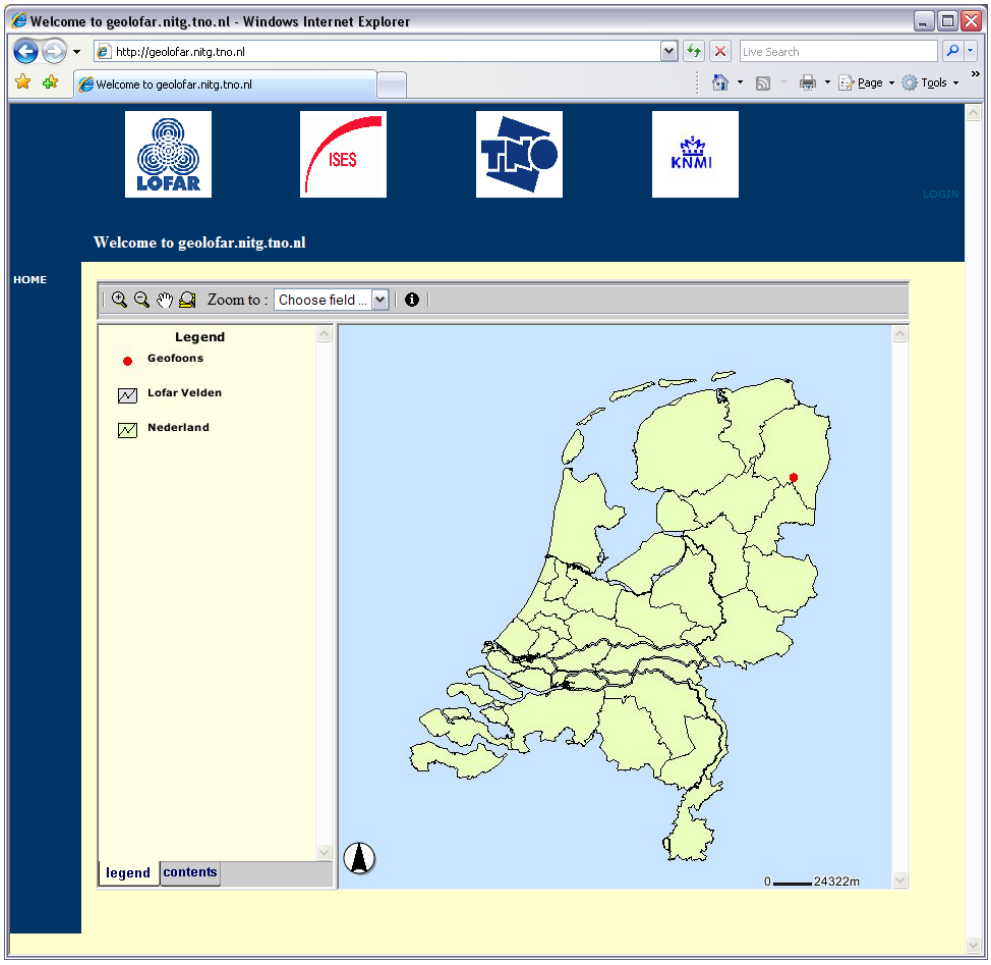
In this screen the structural attributes for AD-converters can be changed. This screen is also used for adding a new AD-converter.

Identifier	An identifier that is unique for this site. Together with the name of the site it is used to
IP Address	The IP Address of the AD-converter
Port	The port number of the AD-converter (default is 9221)
Nr	A sequence number
X	X-coordinate of the AD-converter
Y	Y-coordinate of the AD-converter
sourceDepth	Not applicable
waterDepth	Not applicable
enabled	Let's the user select if this AD-converter is enabled or disabled for the acquisition process. Sampling will only be started for AD-converters that are enabled.

Appendix H: Description of the GeoLOFAR-web site

Hereafter one can find a functional description of the GeoLOFAR -web site, a description of the data functionality that the web site offers and a brief description of the infrastructure that is used.

The GeoLOFAR-web site can be used in a Microsoft Internet Explorer 7 web browser. Other web browser may function as well. The URL of the web site is: http://geolofar.nitg.tno.nl. By entering the URL mentioned above in the address bar of the web browser, the following screen appears:



In this screen we activated the Legend tab and we can see the map of the Netherlands and find on it all the measuring geo-sensors (geophones) and all the LOFAR fields.

By means of a number of tools we can have a closer look at the LOFAR fields on the map. Below a short description follows of the tools that we can use:

Zoom-in, for zooming in to the map by means of a rubber box (mouse drag) or according to a fixed step size;

Zoom-out, for zooming out of the map by means of a rubber box (mouse drag) or according to a fixed step size;

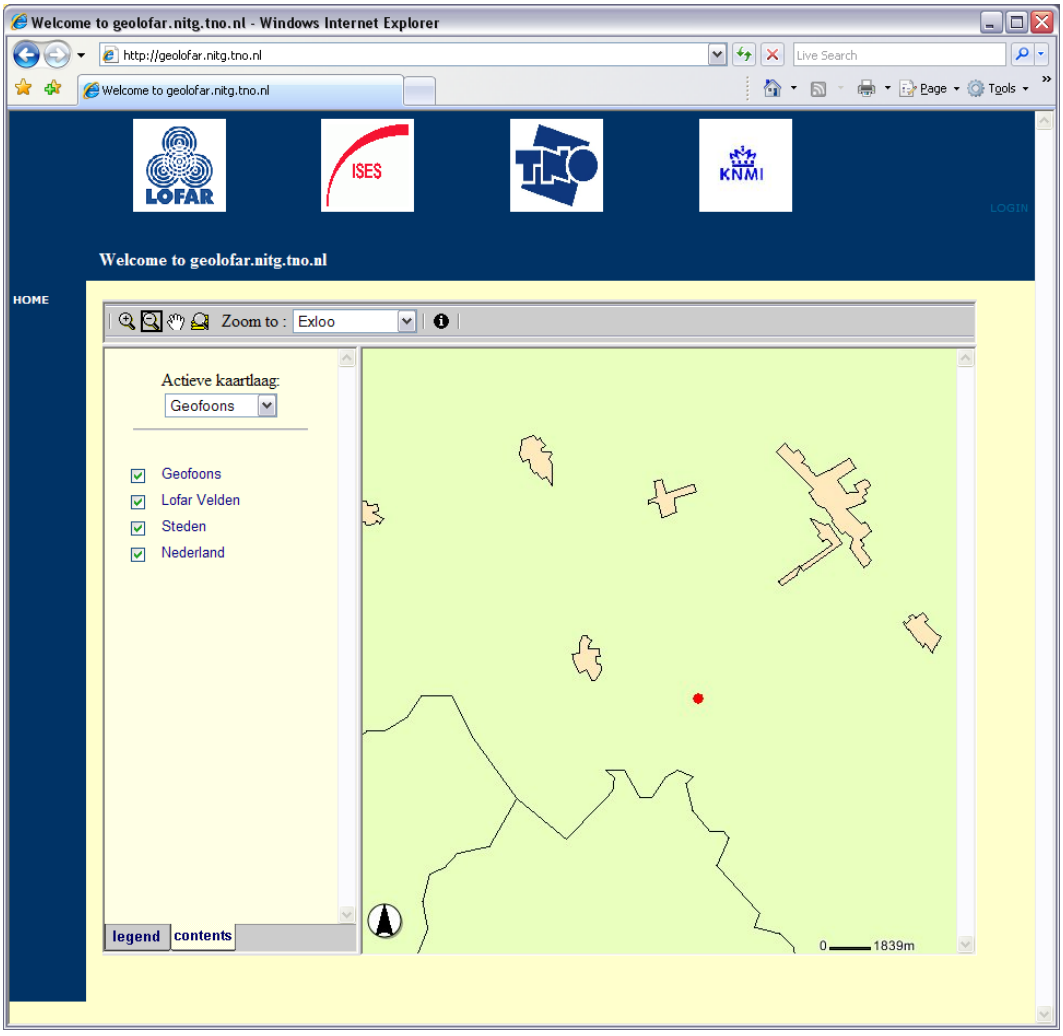
Pan, for moving the map to the right, to the left or up or down (mouse drag);

Zoom-full-extent, for zooming to the full extent of the map;

Zoom-Lofar-field, for zooming to a particular LOFAR field;

Identify, for identifying Seismic sensors and LOFAR fields on the map by showing meta data of these objects and for applying data functions.

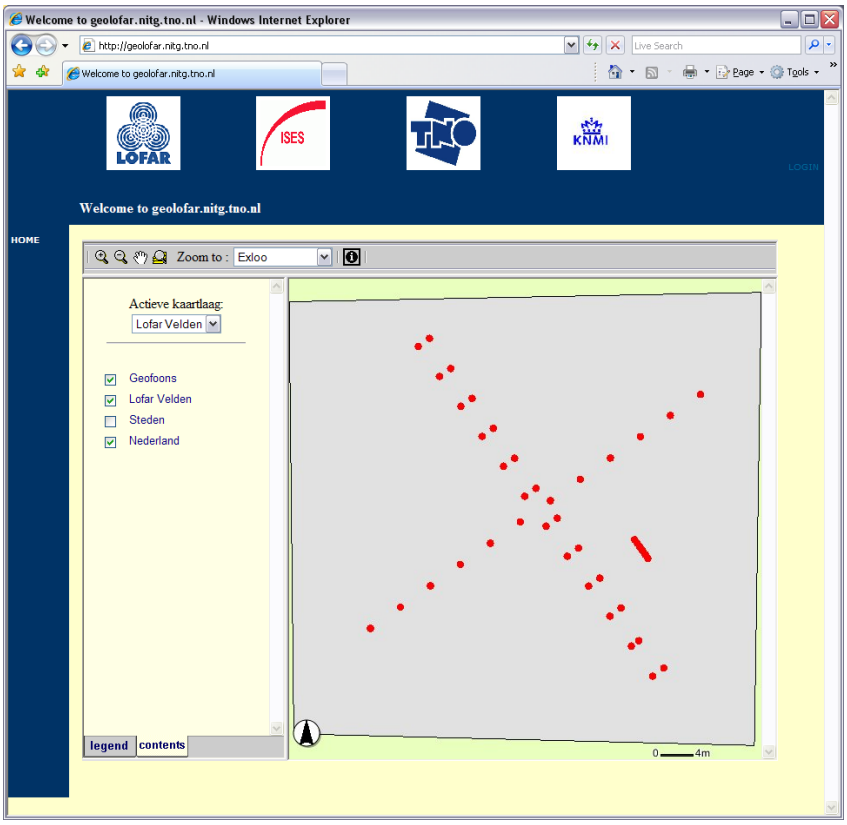
In the next screen we zoomed to the LOFAR field in Exloo by means of the tools described above.



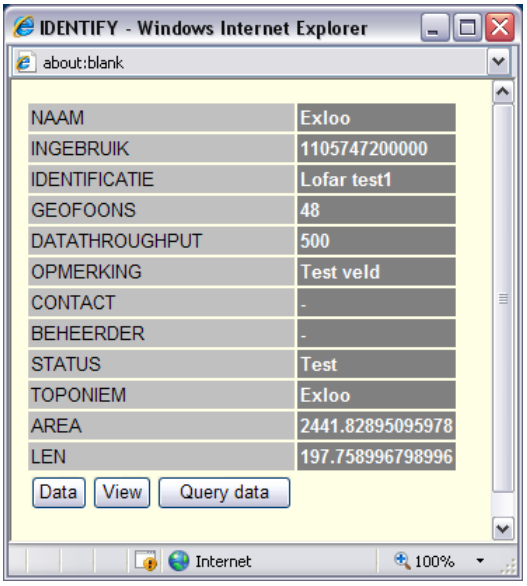
Also we activated the contents tab in this screen. The contents tab allows us to set the visibility of the layers of the map. In the screen above the Seismic Sensors, the LOFAR fields, the Cities and the Netherlands (background map) are set to visible. By means of the layer activity combo box we made the Seismic Sensors layer the active layer. This means that we can use the Identify tool to select a Seismic Sensors on the map with our cursor. After

selecting the Geophone (mouse click), the corresponding Meta-data will appear in a Popup window. By activating other layers we can select elements of those layers at the map and Meta-data of the elements will appear in the popup window.

When we further zoom in to the Exloo field and after we set the City layer to invisible, we get the following screen and we can see the exact position of the available Geophones in the Exloo field.



Because we selected the “Lofar field” layer to be the active map layer, we can select (mouse click) any LOFAR field by means of the Identify tool and have a look at the Meta-data in a popup window.

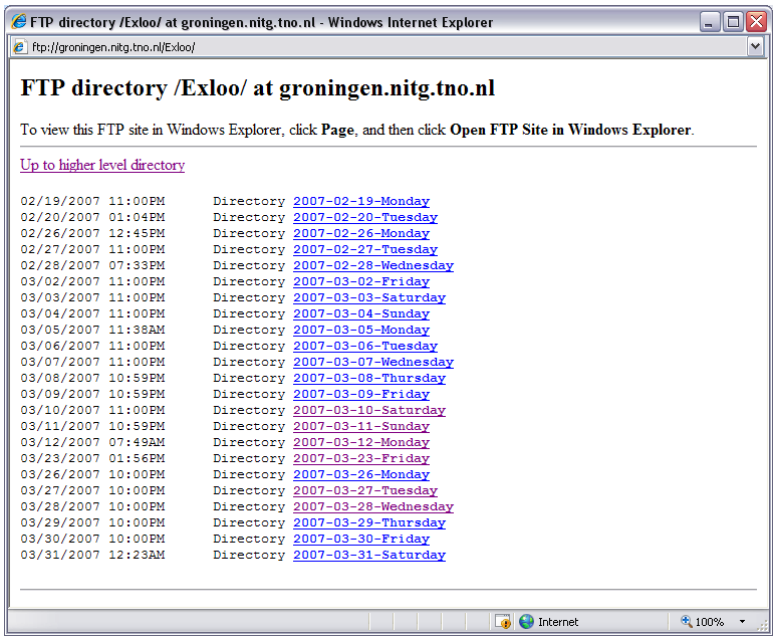


As we can see in the popup window above, we selected the Exloo field, the status is test and we see that 48 Geophones are connected to the LOFAR network. The number attributes of the LOFAR field entity can be extended in the Meta-data database if desired.

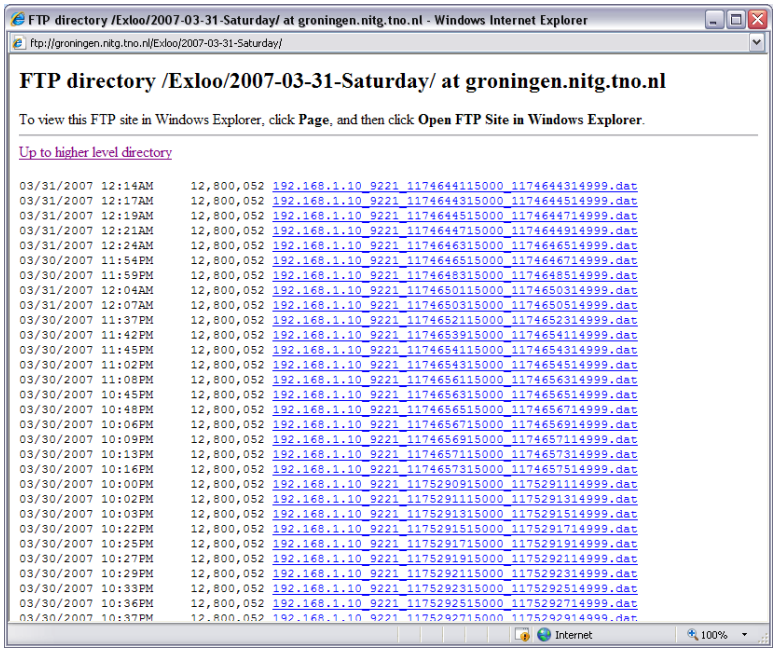
H.1. Data-functionality of the GeoLOFAR-web site

By means of three buttons in the popup window that has been described in the previous paragraph, we are able to apply three data functions to allow us to get measured data from the selected LOFAR field.

Data-function, this function allows browsing through all stored data files. Millions of different data files are stored separately per field and per day.

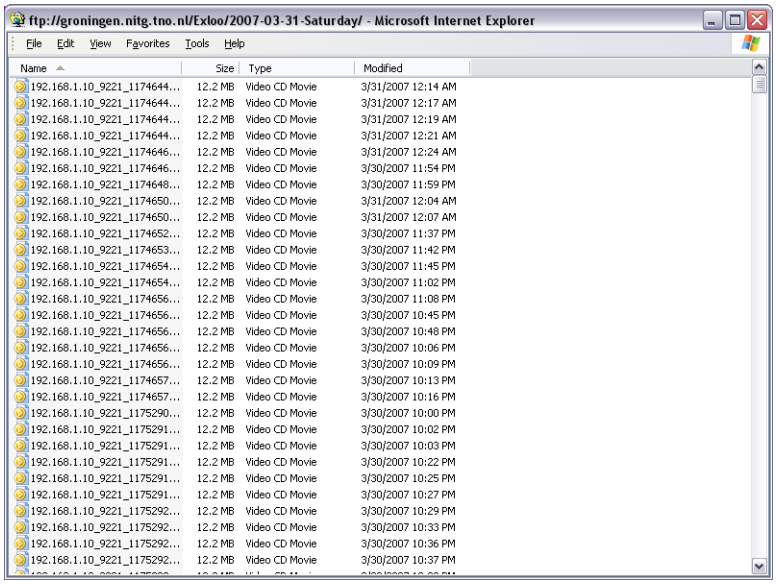

FTP directory /Exloo/ at groningen.nitg.tno.nl - Windows Internet Explorer
ftp://groningen.nitg.tno.nl/Exloo/
FTP directory /Exloo/ at groningen.nitg.tno.nl
To view this FTP site in Windows Explorer, click Page, and then click Open FTP Site in Windows Explorer.
Up to higher level directory
02/19/2007 11:00PM Directory 2007-02-19-Monday
02/20/2007 01:04PM Directory 2007-02-20-Tuesday
02/26/2007 12:45PM Directory 2007-02-26-Monday
02/27/2007 11:00PM Directory 2007-02-27-Tuesday
02/28/2007 07:33PM Directory 2007-02-28-Wednesday
03/02/2007 11:00PM Directory 2007-03-02-Friday
03/03/2007 11:00PM Directory 2007-03-03-Saturday
03/04/2007 11:00PM Directory 2007-03-04-Sunday
03/05/2007 11:38AM Directory 2007-03-05-Monday
03/06/2007 11:00PM Directory 2007-03-06-Tuesday
03/07/2007 11:00PM Directory 2007-03-07-Wednesday
03/08/2007 10:59PM Directory 2007-03-08-Thursday
03/09/2007 10:59PM Directory 2007-03-09-Friday
03/10/2007 11:00PM Directory 2007-03-10-Saturday
03/11/2007 10:59PM Directory 2007-03-11-Sunday
03/12/2007 07:49AM Directory 2007-03-12-Monday
03/23/2007 01:56PM Directory 2007-03-23-Friday
03/26/2007 10:00PM Directory 2007-03-26-Monday
03/27/2007 10:00PM Directory 2007-03-27-Tuesday
03/28/2007 10:00PM Directory 2007-03-28-Wednesday
03/29/2007 10:00PM Directory 2007-03-29-Thursday
03/30/2007 10:00PM Directory 2007-03-30-Friday
03/31/2007 12:23AM Directory 2007-03-31-Saturday
Internet
100%

After pushing the data function button, the screen above appears which gives us an overview of all the data files of the selected LOFAR field. This screen allows us to look further for data files of a certain date, by selecting a day in the list (mouse click).

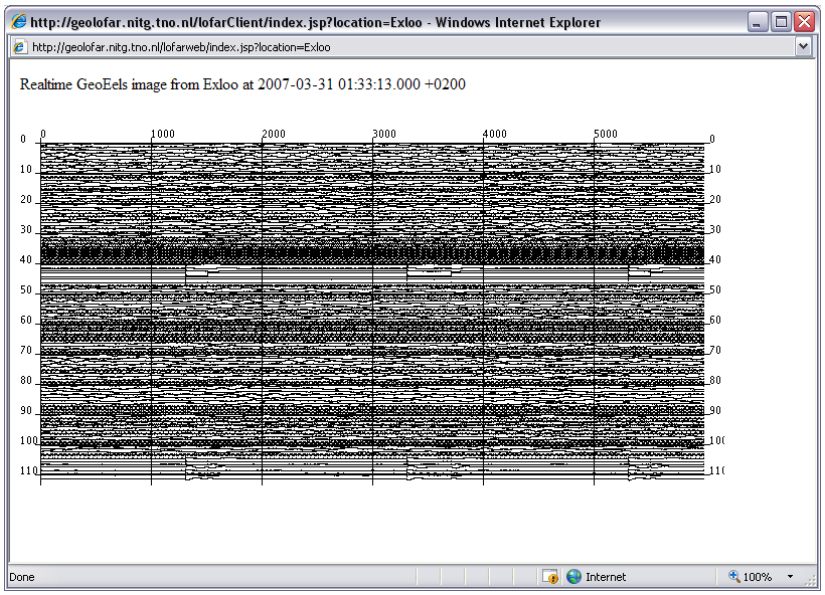


Finally we can download the data files by selecting and downloading the files to our local work station.

Also it is possible to look for data files in a Windows file explorer. By copying the FTP-URL in the screens and pasting this URL in the address bar of the file explorer, all the data files can be examined as if they were files on a local disk. Thus, copying more than one data file at the time or using data files directly in a desktop application is possible.

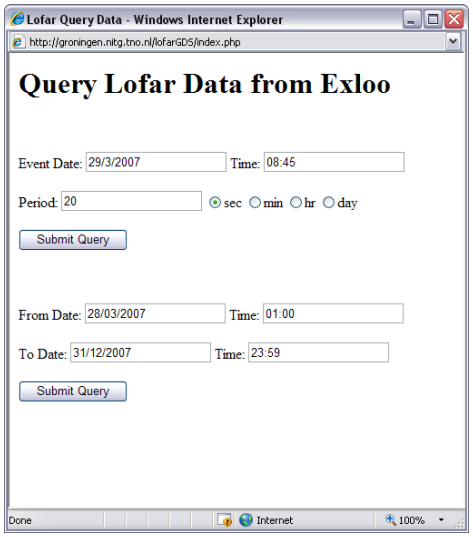


View-function, the view function gives us a graphical over view of all recently measured data. The overview appears in a popup window and is being refreshed automatically every six seconds. In the overview all measurements of all available data channels are taken into account.

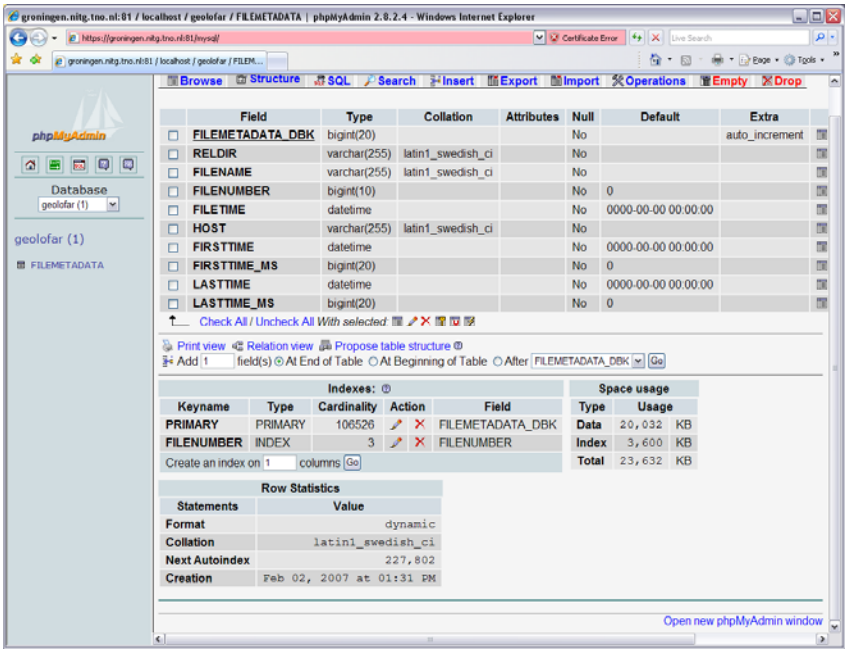


Query data-function, the query data function helps us to find data files of a certain period in time. By means of the Query window below we have the possibility to formulate two types of questions:

- All data files around a certain event in time or
- All data files with a certain time interval.

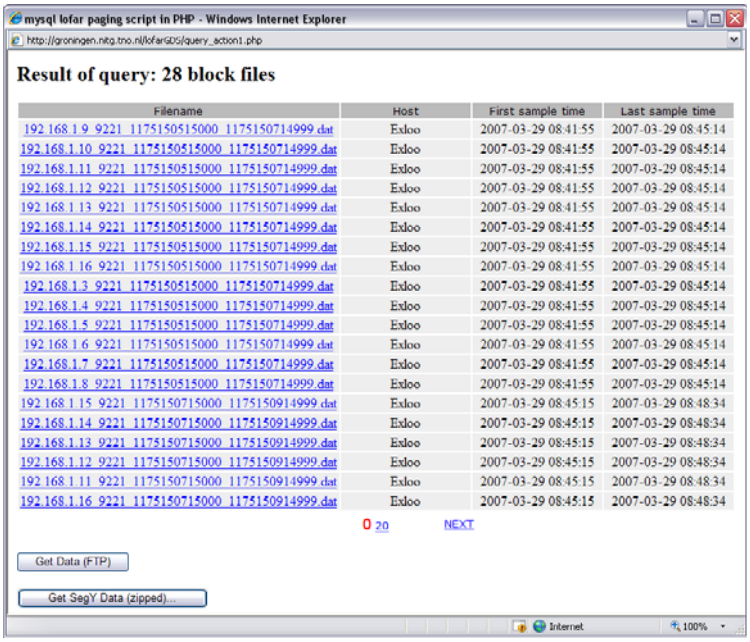


For the quick retrieval of the desired data file according to the given search criteria, a GeoLOFAR Meta-data database is has been developed. In this database all aspects of the measured data and all the attributes of each data file are being stored. An overview of the structure of the file meta-data-table that is being used to store the Meta-data is given in the next screen.

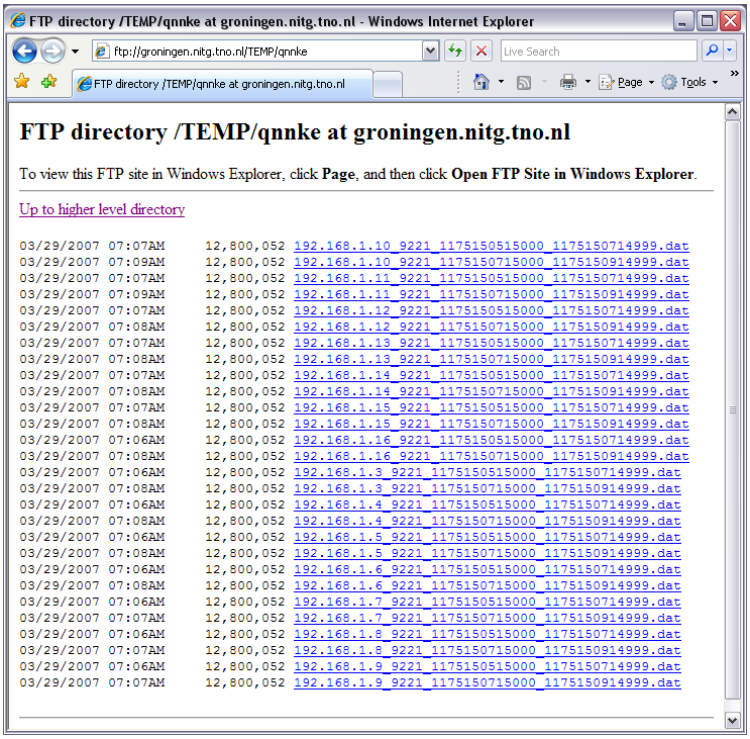

groningen.nitg.tno.nl:81 / localhost / geolofar / FILEMETADATA | phpMyAdmin 2.8.2.4 - Windows Internet Explorer
Browse Structure SQL Search Insert Export Import Operations Empty Drop
Field Type Collation Attributes Null Default Extra
FILEMETADATA_DBK bigint(20) No auto_increment
RELDIR varchar(255) latin1_swedish_ci No
FILENAME varchar(255) latin1_swedish_ci No
FILENUMBER bigint(10) No 0
FILETIME datetime No 0000-00-00 00:00:00
HOST varchar(255) latin1_swedish_ci No
FIRSTTIME datetime No 0000-00-00 00:00:00
FIRSTTIME_MS bigint(20) No 0
LASTTIME datetime No 0000-00-00 00:00:00
LASTTIME_MS bigint(20) No 0
Check All / Uncheck All With selected
Print view Relation view Propose table structure
Add 1 field(s) At End of Table At Beginning of Table After FILEMETADATA_DBK Go
Indexes:
Keyname Type Cardinality Action Field
PRIMARY PRIMARY 106526 FILEMETADATA_DBK
FILENUMBER INDEX 3 FILENUMBER
Create an index on 1 columns Go
Space usage
Type Usage
Data 20,032 KB
Index 3,600 KB
Total 23,632 KB
Row Statistics
Statements Value
Format dynamic
Collation latin1_swedish_ci
Next Autoindex 227,802
Creation Feb 02, 2007 at 01:31 PM
Open new phpMyAdmin window

Finally the file meta-data-table will contain many of millions of meta-data attributes of all stored data files.

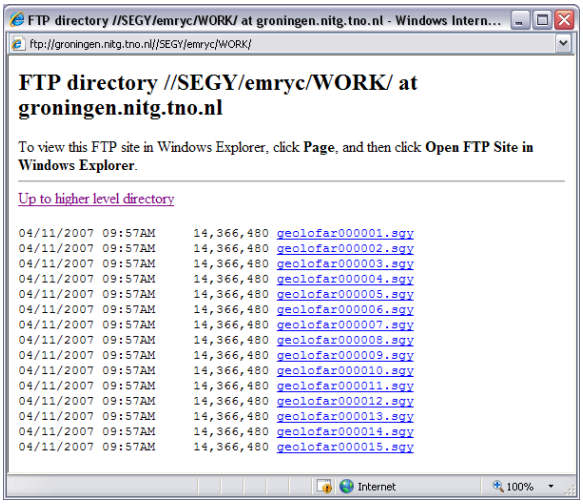
After applying the query to the database the result will appear in table layout.



In this table we can browse through all data files that are adopted in the result. Also it is possible to create an overview from this table with the layout like the one that is being used at the data-button functionality described earlier (Get data (FTP)).

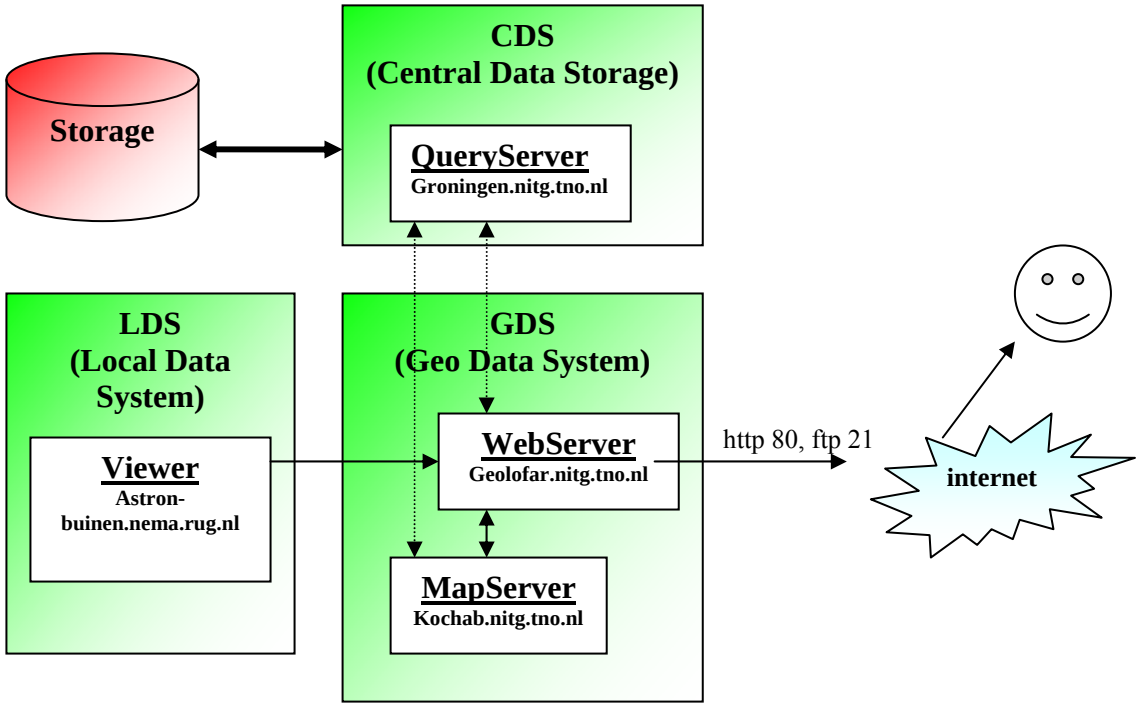


The result can also be transformed to a SEGY-format table (Get SEGY Data), so that the data can be used directly in PC-desktop applications that work with the SEGY format.


FTP directory //SEGY/emryc/WORK/ at groningen.nitg.tno.nl - Windows Intern...
ftp://groningen.nitg.tno.nl//SEGY/emryc/WORK/
FTP directory //SEGY/emryc/WORK/ at groningen.nitg.tno.nl
To view this FTP site in Windows Explorer, click Page, and then click Open FTP Site in Windows Explorer.
Up to higher level directory
04/11/2007 09:57AM 14,366,480 geolofar000001.sgy
04/11/2007 09:57AM 14,366,480 geolofar000002.sgy
04/11/2007 09:57AM 14,366,480 geolofar000003.sgy
04/11/2007 09:57AM 14,366,480 geolofar000004.sgy
04/11/2007 09:57AM 14,366,480 geolofar000005.sgy
04/11/2007 09:57AM 14,366,480 geolofar000006.sgy
04/11/2007 09:57AM 14,366,480 geolofar000007.sgy
04/11/2007 09:57AM 14,366,480 geolofar000008.sgy
04/11/2007 09:57AM 14,366,480 geolofar000009.sgy
04/11/2007 09:57AM 14,366,480 geolofar000010.sgy
04/11/2007 09:57AM 14,366,480 geolofar000011.sgy
04/11/2007 09:57AM 14,366,480 geolofar000012.sgy
04/11/2007 09:57AM 14,366,480 geolofar000013.sgy
04/11/2007 09:57AM 14,366,480 geolofar000014.sgy
04/11/2007 09:57AM 14,366,480 geolofar000015.sgy
Internet
100%

H.2. Infrastructure of the GeoLOFAR website

The infrastructure that is being used by the GeoLOFAR-web site is as follows:



We have the following infrastructure components:

- **Web Server**, a Jahia Content Management System with one iFrame that contains the Map of the Map Server;
- **Map Server**, a set of JSP files, JavaScript files and a link to an ArcIMS server that serves the GeoLOFAR Map.
- **Query Server**, an Apache2 web server that is PHP-enabled, a number of PHP-scripts and a link to the GeoLOFAR MySQL database engine;
- **Viewer**.

A detailed description of the Viewer component can be found in a separate document: Geolofar_Viewer.doc.

Appendix I: Failover and recovery

To create a reliable server infrastructure each server type has his own failover system that fits to his purpose. The following Raid options are implemented.

*Description***:** RAID 1 is usually implemented as mirroring; a drive has its data duplicated on two different drives using either a hardware RAID controller or software (generally via the operating system). If either drive fails, the other continues to function as a single drive until the failed drive is replaced. Conceptually simple, RAID 1 is popular for those who require fault tolerance and don't need top-notch read performance. A variant of RAID 1 is duplexing, which duplicates the controller card as well as the drive, providing tolerance against failures of either a drive or a controller. It is much less commonly seen than straight mirroring.

*Description***:** RAID 05 and 50 form large arrays by combining the block striping and parity of RAID 5 with the straight block striping of RAID 0. RAID 05 is a RAID 5 array comprised of a number of striped RAID 0 arrays; it is less commonly seen than RAID 50, which is a RAID 0 array striped across RAID 5 elements. RAID 50 and 05 improve upon the performance of RAID 5 through the addition of RAID 0, particularly during writes. It also provides better fault tolerance than the single RAID level does, especially if configured as RAID 50.

For the complete server hardware description and the used failover and recovery see appendix J.

Appendix J: Computer Hardware

In this network we identify two types of servers. Depending on the server task a system configuration, failover and recovery plan is made. In a later stadium we may have to reconsider the system configurations storage size depending on the life time of the data.

The identified server types are:

1 Central servers for storing and providing data, like the CDS and GMS
2 Field server, like the LDS

The central servers (Dell PowerEdge 1850) placed in Groningen are critical in the process so extra actions have been taken to make those servers more reliable. The Storage attached to the CDS (Dell PowerVault MD1000) that stores the data is capable of storing 6 TBytes of data. This Storage can be extended to 22.5 TBytes by simple adding new Storage cabinets to the CDS.

Each server has minimal a mirrored disk for the operating System and the hardware for all the servers is the same, except for the Field Gateways. The Central Data Storage has a raid 50 with hot spare so that disks can be replaced online. There are no backup facilities because there is no time to recover the lost data. See appendix I "Failover and recovery".

A LDS is a regular PC (Dell Optiplex GX620) as non-critical parts of the network. In the network there are 45 LDS systems so a simple and cost efficient solution is preferred. The only non standard thing is the amount of memory of 4GBytes. This is done to install Vmware. This Vmware makes it possible to create virtual PCs on one PC. We use a virtual Microsoft Windows Professional XP for using test and calibration software for the AD converters. Each LDS system has a power switch that is accessible by the internet for resetting the complete system. This power switch makes it possible to restart the LDS and all the AD converters as the last chance to solve a problem in the communication. The size of the hard disk in the LDS is

	Operating System	Redundant power supply	Memory	Disk Raid	Disksize	Example type
Local Data System (LDS)	Linux/VMware Virtual Windows Professional XP	No	4 GBytes	0	500 GB	Dell Optiplex GX620
Central Data Storage (CDS)	Linux	Yes	4 GBytes	- Server: RAID 1 - Storage (Raid 50 + hot spare)	- server 147 GBytes - Storage 15 * 500 GBytes	Dell PowerEdge 1950 + Dell PowerVault MD100

DELL POWERVAULT MD1000 MODULAR DISK STORAGE EXPANSION ENCLOSURE

The storage enclosure that's spearheading a new era of performance, expandability, and versatility for Dell.

Versatile Storage Expansion

The Dell™ PowerVault™ MD1000 is a modular disk storage expansion enclosure for PowerEdge™ servers capable of housing up to fifteen 3.5-inch disk drives in a single 3U rackable chassis. The direct attached storage enclosure supports both Serial Attached SCSI (SAS) and Serial ATA (SATA) disk drives to give customers extensive configuration and optimization flexibility.

SAS Performance

SAS, the latest advancement in proven SCSI disk drive technology, is used for a variety of enterprise applications because of its high performance and excellent reliability. When configured with SAS disk drives, the expansion enclosure can satisfy the storage requirements of mainstream and demanding email, database, OLTP (online transaction processing), data warehousing and other I/O-intensive applications running on a single server.

The serial architecture of SAS offers key bandwidth improvements over parallel SCSI. For example, SAS employs a point-to-point topology that delivers dedicated bandwidth to each drive. Additionally, SAS ports can be aggregated to deliver bandwidth capacity up to nearly four-times (4X) that of a SCSI bus.

The storage enclosure supports the best-of-breed 3.5-inch disk drive form factor and supports both 10,000 and 15,000 RPM spindle speeds. Today, SAS drives with 15,000 RPM spindle speeds—well-suited for handling random database-type transactions—are available only in the 3.5-inch form factor.

SATA Value

Now in its second generation, SATA II disk drives have been enhanced to better handle the rigors of some enterprise applications. SATA II disk drives are well-suited for bandwidth-intensive applications with long continuous data transfers, including audio/video streaming or disk backup and restore. In addition, SATA II drives have a low cost-per-Gigabyte, making them ideal for affordable storage of large amounts of infrequently accessed information, such as fixed content, file archives, reference material, and the like.

Modular Expansion Flexibility

When used in combination with a host-based Dell PowerEdge RAID controller (PERC), the modular enclosure can be daisy chained for scaling disk performance and capacity. The PERC 5/E enables up to three 15-drive SAS disk enclosures—a total of 45 drives—to be daisy chained to a single host connection, delivering an extended total capacity of 13.5TB* when using 300GB* SAS drives or 22.5TB* using 500GB* SATA II disk drives. Alternatively, the enclosure's disk drives can be split between two servers with up to eight drives assigned to one server and up to seven drives assigned to a second server. Furthermore, the enclosure's disk drives, power supplies and cooling modules are hot-pluggable so they can be replaced while the system stays up-and-running.

PowerEdge Server Commonality

PowerVault disk storage products are designed and engineered for PowerEdge servers, optimized for performance and reliability, then tested and validated to help simplify deployment and management. To help improve serviceability of disk drives, the PowerVault MD1000 is equipped with a common drive carrier that can be used on select Dell servers.

The PERC 5/E SAS RAID controller—sold separately—includes Dell OpenManage™ Server Administrator Storage Manager. This management software package provides a complete set of disk configuration and administrative utilities for both internal and external server-resident disk drives.

Dell Services are available to help streamline the installation and ongoing operations of your disk expansion enclosure. These services include Dell Enterprise Support Services, Professional Installation Services and Disk Expansion Training.

Dell PowerVault MD1000

DELL POWERVAULT MD1000 DISK EXPANSION ENCLOSURE

DELL IT INFRASTRUCTURE SERVICES

Dell™ brings pure execution to IT Services. The planning, implementation and maintenance if your IT infrastructure deserves nothing less. Variability in execution can compromise user productivity, IT resources, and ultimately, your reputation. By leveraging our heritage of process driven excellence, Dell Services can deliver a smarter way.

We don't claim to do everything. We focus on IT infrastructure services. And we take a customer led approach, grounded in the philosophy that you know your business better than anyone. That's why Dell does not try to take key business decisions out of your hands, or lock you in to more than you need. Instead, we apply our world-class process management and "no excuses" culture to deliver what customers today most need – flexibility and repeatable quality. That's pure execution. That's Pure Dell.

Assessment, Design and Implementation Services
IT departments are continually challenged to evaluate and implement new technologies. Dell's assessment, design and implementation services can restructure your IT environment to enhance performance, scalability and efficiency while helping to maximize your return on investment and minimize disruption to your business.

Deployment Services
System deployment is a necessary evil that plagues nearly every organization. You must deploy new systems to help improve performance and meet user demand. With Dell's deployment services, we help simplify and speed up the deployment and utilization of new systems to maximize uptime throughout your IT environment.

Asset Recovery and Recycling Services
Proper disposal, reselling and donation of computer equipment is a time-consuming task that typically falls to the bottom of many IT to-do lists. Dell helps simplify the end of life processes for IT equipment in a way that can maximize value for customers.

Training Services
Arm your employees with the knowledge and skills they need to be as productive as possible. Dell offers comprehensive training services which include hardware and software training, as well as PC skills and professional development classes. With Dell training you can help improve system reliability, maximize productivity and reduce end user requests and downtime.

Enterprise Support Services
With Dell, you can get maximum performance and availability of your Dell server and storage systems. Our Enterprise Support services offer proactive maintenance to help prevent problems as well as rapid response and resolution of problems when they do occur. We have built a robust global infrastructure that offers multiple levels of enterprise support for systems throughout your infrastructure.

To help you get the most from your Dell systems, visit www.dell.com/services.

Services vary by region.

FEATURES	DESCRIPTION
DRIVES AND CAPACITY	
Hard drives	Up to fifteen (15) 1-inch-by-3.5-inch SAS hot-pluggable 3.0 Gbps hard drives, at speeds of 10,000 or 15,000 RPM; Up to fifteen (15) 1-inch-by-3.5-inch SATA II hot-pluggable 3.0 Gbps hard drives, at speeds of 7,200 RPM
Drive speeds and capacities	15,000 RPM SAS drives available in 36GB, 73GB, or 146GB 10,000 RPM SAS drives available in 73GB, 146GB, or 300GB 7,200 RPM SATA II drives available in 250GB or 500GB
Minimum capacity* (per enclosure)	72GB using two 36GB 15,000 RPM drives
Maximum capacity* (per enclosure)	7,500GB using fifteen 500GB 7,200 RPM SATA II disk drives in one enclosure
Maximum capacity* (per RAID connection)	22,500GB using forty-five 500GB 7,200 RPM SATA II disk drives in three enclosures
CONNECTIVITY	
Configurations	Support for either of the following configurations: Unified mode for direct connectivity to 15 disk drives and beyond; Split mode with dual Enclosure Management Modules providing direct connectivity to drives 0 though 6 and a separate connectivity to drives 7 through 14
ENCLOSURE MANAGEMENT MODULES (EMM)	
EMMs	1 or 2 hot-pluggable modules
BACKPLANE BOARD	
Connectors	15 SAS disk drive connectors; 2 power supply/cooling fan module connectors; 2 sets of EMM connectors (6 connectors each EMM); 1 control panel connector for front LEDs and enclosure mode switch
Sensors	2 temperature sensors
BACK-PANEL CONNECTORS	
SAS connectors (per EMM)	One 12.0 Gbps SAS (SFF 8470) "IN" connector for connection to the host; One 12.0 Gbps SAS (SFF 8470) "OUT" connector for expansion to an additional enclosure
Serial connector (per EMM)	1 6-pin UART mini-DIN connector (for factory use only)
LED INDICATORS	
Front panel	1 two-color LED indicator for system status; 2 single-color LED indicators for power and split mod
Hard-drive carrier	1 single-color activity LED; 1 two-color LED status indicator per drive
EMM	3 two-color LED status indicators: one each for the two EMM SAS ports and one for the EMM status
Power supply/cooling fan module	3 LED status indicators for power supply status, power supply/fan fault and AC status
POWER SUPPLIES	
Wattage	488 W maximum continuous; 550 W peak
Heat dissipation	200 W
Voltage	100–240 V rated (actual 90–264 V)
Frequency	47–63 Hz
Amperage	7.2 A at 100 V, 3.6 A at 200 V
AVAILABLE HARD DRIVE POWER (PER SLOT)	
Supported consumption	Up to 1.3 A at +12 V; Up to 1.5 A at +5 V
PHYSICAL	
Height	13.11 cm (5.16 inches)
Width	44.63 cm (17.57 inches)
Depth	48.01 cm (18.9 inches)
Weight	35.37 kg (78 lb) (maximum configuration)
ENVIRONMENTAL	
Temperature	
Operating	10° to 35°C (50° to 95°F)
Storage	-40° to 65°C (-40° to 149°F)
Relative humidity	
Operating	20% to 80% (non-condensing)
Storage	5% to 95% (non-condensing)
Altitude	
Operating	-16 to 3048 m (-50 to 10,000 ft)
Storage	-16 to 10,600 m (-50 to 35,000 ft)
BTU per hour	1430

Dell is not responsible for errors in typography or photography.

*For hard drives, GB means 1 billion bytes and TB equals 1 trillion bytes; actual capacity varies with preloaded material and operating environment and will be less.

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DELL POWEREDGE 1950 SERVER

In a 1U form factor, the Dell™ PowerEdge™ 1950 delivers the right combination of computing power and redundancy in an ultra-dense chassis. With dual-processor performance, next generation manageability and platform commonality, it is ideal for edge-of-network, infrastructure, SAN front-end, thin client-server and High Performance Computing Clusters (HPCC) applications.

Dell PowerEdge 1950

Dell's Innovative 9th Generation PowerEdge Servers

Through innovative hardware design, software commonality and continued focus on fewer system updates, Dell's 9th generation PowerEdge servers help reduce the complexity involved in managing data, whether you are a large enterprise or a small business. These servers are designed to a Dell™-developed Behavioral Specification that defines consistent hardware layout and user interaction across all server models in this and future PowerEdge generations. Plus, a shared master system image with 2950 and 2900 enables updates to BIOS, system drivers, firmware, operating systems and applications from one easy-to-copy template for simplified software management. Featuring the latest Intel® Xeon® processors, the 9th generation PowerEdge servers offer the power and performance you expect from Dell.

Dell PowerEdge 1950 Delivers Performance in a Space-Conscious Form Factor

The Dell PowerEdge 1950 server provides exceptional performance and availability for organizations that require high-powered processing capability in a space-constricted data center. The rack-dense 1U server features 64-bit, Quad-Core Intel Xeon processors and the latest in chipset, memory and I/O technology. The result is incredible performance and scalability to handle heavy workloads today and in the future without data center sprawl.

The Dell PowerEdge 1950 includes twice the memory capacity of 8th generation servers with up to 32GB of fully-buffered DIMM memory which allows scalability and greater performance, especially in virtualized workloads. PCI-Express™ I/O slots support high performance Ethernet, RAID, InfiniBand and Fibre Channel interconnects while helping to provide investment protection for future technologies. Finally, Serial Attach SCSI (SAS) hard drives can deliver some of the highest possible performance available with the next generation storage technology while SATA drive options offer greater value for systems that rely on internal or external storage and fiber channel storage options.

Availability to Help Maximize Uptime Without Sacrificing Density

Now you don't have to compromise space for redundancy and availability. The Dell PowerEdge 1950 server maximizes redundancy with hot-plug redundant power supplies, hot-plug hard drives accessible through the front of the server and redundant cooling. It also includes dual embedded Gigabit NICs and PCI slots on separate buses for flexible expandability. Additionally, optional integrated RAID controller with battery-backed cache offers improved reliability and system uptime.

Manageability for Reduced Complexity

The Dell PowerEdge 1950 server is equipped with a Baseboard Management Controller (BMC) that includes a complete set of tools that monitors server hardware, alerts you when server faults occur and enables basic remote operations. For environments with servers located in secure data centers or in sites with no IT staff, Dell offers an optional feature for PowerEdge servers, the Dell Remote Access Controller (DRAC). Operated through a Web-based graphic user interface, DRAC can enable remote access, monitoring, troubleshooting, repair and upgrades independent of the operating system status. Common software with the same family of PowerEdge 9th generation servers further helps simplify management. Plus, the Dell Behavioral Specification means one familiar platform for less complex deployment, management and serviceability as well as lower Total Cost of Ownership (TCO) over multiple generations of PowerEdge servers.

DELL POWEREDGE 1950 SERVER

DELL IT INFRASTRUCTURE SERVICES

Dell brings pure execution to IT Services. The planning, implementation and maintenance of your IT infrastructure deserves nothing less. Variability in execution can compromise user productivity, IT resources and ultimately, your reputation. By leveraging our heritage of process driven excellence, Dell Services can deliver a smarter way.

We don't claim to do everything. We focus on IT infrastructure services. And we take a customer led approach, grounded in the philosophy that you know your business better than anyone. That's why Dell does not try to take key business decisions out of your hands, or lock you into more than you need. Instead, we apply our world-class process management and "no excuses" culture to deliver what customers today most need – flexibility and repeatable quality. That's absolute execution. That's Dell.

Assessment, Design and Implementation Services

IT departments are continually challenged to evaluate and implement new technologies. Dell's assessment, design and implementation services can restructure your IT environment to enhance performance, scalability and efficiency while helping to maximize your return on investment and minimize disruption to your business.

Deployment Services

System deployment is a necessary evil that plagues nearly every organization. You must deploy new systems to help improve performance and meet user demand. With Dell's deployment services, we help simplify and speed up the deployment and utilization of new systems to maximize uptime throughout your IT environment.

Asset Recovery and Recycling Services

Proper disposal, reselling and donation of computer equipment is a time-consuming task that typically falls to the bottom of many IT to-do lists. Dell simplifies the end of life processes for IT equipment in a way that can maximize value for customers.

Training Services

Arm your employees with the knowledge and skills they need to be as productive as possible. Dell offers comprehensive training services which include hardware and software training, as well as PC skills and professional development classes. With Dell training you can help improve system reliability, maximize productivity and reduce end user requests and downtime.

Enterprise Support Services

With Dell, you can get maximum performance and availability of your Dell server and storage systems. Our Enterprise Support services offer proactive maintenance to help prevent problems as well as rapid response and resolution of problems when they do occur. We have built a robust global infrastructure that offers multiple levels of enterprise support for systems throughout your infrastructure.

To help you get the most from your Dell systems, visit www.dell.com/services.

Services vary by region.

www.dell.com

FEATURES	DELL™ POWEREDGE™ 1950 SERVER
Form factor	1U rack height
Processors	Up to two Quad-Core Intel Xeon 5300 sequence processors at up to 2.66GHz; Up to two Dual-Core Intel Xeon 5100 sequence processors at up to 3.0GHz; Up to two Dual-Core Intel Low Volt Xeon 5148 processor at 2.33GHz; Up to two Dual-Core Intel Xeon 5000 sequence processors at up to 3.0GHz
Front side bus	Intel Xeon 5300 Sequence: Dual Independent 1066MHz or 1333MHz; Intel Xeon 5100 Sequence: Dual Independent 1066MHz or 1333MHz; Intel Xeon 5000 Sequence: Dual Independent 667MHz
Cache	Intel Xeon 5300 Sequence: 2x4MB; Intel Xeon 5100 Sequence: 4MB; Intel Xeon 5000 Sequence: 2x2MB
Chipset	Intel 5000X
Memory	256MB/512MB/1GB/2GB/4GB Fully Buffered DIMMs (FBD) in matched pairs; 533MHz or 667MHz; 8 sockets for support up to 32GB
I/O slots	Two slots on separate PCI buses with either PCI Express riser with two x8 lane slots or PCI-X riser with 2 x 64-bit/133MHz slots
Drive controller	Optional PERC 5/i integrated SAS/SATA daughtercard controller with 4 port SAS 5/i integrated SAS controller (no RAID)
RAID controller	Optional PERC 5/i integrated SAS/SATA daughtercard controller with 256MB cache, PERC4e/DC, PERC 5/e adapter
Drive bays	Two options: Two hard drive chassis with 2 x 3.5" SAS (10K/15K) or SATA (7.2K) drives or four hard drive chassis with 4 x 2.5" SAS (10K) drives; Peripheral bays: 1 slim optical drive bay with choice of optional CD-ROM, optional DVD-ROM or combo CD-RW/DVD-ROM
Maximum internal storage	Up to 600GB: two 300GB hot-plug 3.5" SAS (10K RPM); Up to 1.5TB: two 750GB hot-plug 3.5" SATA (7.2K RPM)
Hard drives[1]	2.5" SAS (10K RPM): 36GB, 73GB; 3.5" SAS (10K RPM): 73GB, 146GB, 300GB; 3.5" SAS (15K RPM): 36GB, 73GB, 146GB; 3.5" SATA (7.2K RPM): 80GB, 160GB, 250GB, 500GB, 750GB SATAu
Internal storage	Optional bootable CD-ROM; 2 x 3.5" hot-plug SAS (10K and 15K) or SATA (7.2K) drives; 4 x 2.5" hot-plug 10K SAS drives
External storage	Dell PowerVault™ 22xS, PowerVault MD1000, Dell/EMC products
Tape backup options	Internal: none External: PowerVault DAT 72, 110T, 114T, 122T, 124T, 132T, 136T,160T and ML6000
Network interface card	Dual embedded Broadcom® NetXtreme II™ 5708 Gigabit[2] Ethernet NIC with fail-over and load balancing; TOE (TCPIP Offload Engine) supported on Microsoft Windows Server 2003, SP1 or higher with Scalable Networking Pack.
Power supply	670W, optional hot-plug redundant power (1+1)
Availability	Hot-plug hard drives; hot-plug redundant power; redundant cooling; ECC memory; Spare Row; Single Device Data Correction (SDDC); /PERC 5/i integrated daughter card with battery-backed 256MB DDR2 cache; high availability failover cluster support; DRAC5
Video	Embedded ATI ES1000 with 16MB memory
Remote management	Standard Baseboard Management Controller with IMPI 2.0 support; optional DRAC5 for advanced capabilities
Systems management	Dell OpenManage™
Rack support	4-post (Dell rack), 2-post and 3rd party Versa rails, sliding rails and Cable Management Arm
Operating systems	Microsoft® Windows® Server™ 2003 R2, Standard, Enterprise & Web Editions, x64 R2; Standard & Enterprise editions; Red Hat® Linux® Enterprise v4, ES & WS EM64T, ES & WS; SUSE® Linux® Enterprise Server 9 EM64T

[1] For hard drives, GB means 1 billion bytes, actual capacity varies with preloaded material and operating environment and will be less.
[2] This term does not connote an actual operating speed of 1GB/sec. For high speed transmission, connection to a Gigabit Ethernet server and network infrastructure is required.

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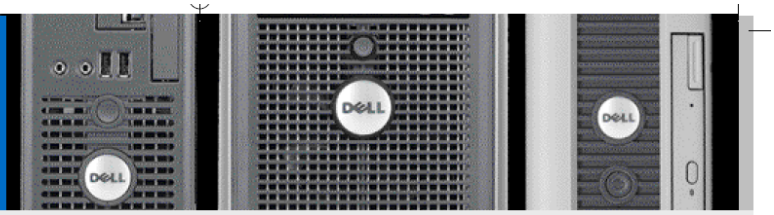
Dell OptiPlex GX620 and GX520



The GX620 and the GX520 are designed for the enterprise customer who is looking for performance, stability and flexibility in the workplace. The GX620 and GX520 extend industry-leading solutions through customer-driven innovation, environmental responsibility and excellent customer choice by offering seven different chassis choices sharing one single image. This helps to provide excellent image stability and a low ownership cost. The GX520 provides integrated desktop innovations for customers seeking a robust mainstream business solution, while the GX620 offers all the benefits of the GX520 plus maximum flexibility, security and investment protection including the new Intel® Pentium® D dual-core processor.

Direct Detect™ keeps the pulse on the health of your system

- Provides quick and convenient status indication of your hard-drive activity, network connectivity and overall system health

Usability at your fingertips

- USB ports are conveniently located on the front of the system for easy access and spacing for side-by-side installation of USB devices

Innovative BTX design

- Dell™'s standard BTX chassis design, power supply and motherboards are designed for thermal efficiency, providing improved reliability and quieter operation compared to previous OptiPlex™ models

Innovative HyperCool™ system

- Dell's HyperCool thermal management technology uses variable-speed fans that provide optimal cooling with less power and enables quieter operation compared to previous OptiPlex models

Solution for every space

- The GX620 offers the ultra-small form factor and the small form factor chassis with an innovative all-in-one solution for space-constrained environments
- The GX520 includes this offering on the small form factor chassis

Environmental peace of mind

- Environmentally conscious design with RoHS-compliant configurations available[1]
- Waste reduction via customer-selectable documentation and media at the point of purchase
- Compliant straight from the factory with ENERGY STAR®, TCO and Blue Angel
- Asset recovery and disposal services available

Dell services help make OptiPlex desktops easier to deploy and easier to manage

- Image management – helps reduce image management complexity and costs by assisting customers with image development, testing and validation
- Custom Factory Integration – key services include custom image load, asset tagging and management, and custom hardware installation
- Deployment – Dell can arrange for custom logistics and delivery as well as installation of new systems and removal of old hardware

Easy as DELL™

Visit **www.euro.dell.com** for more information.

Dell OptiPlex GX620 and GX520

Dell™ recommends Microsoft® Windows® XP Professional

SYSTEM

Operating Systems ..... Microsoft® Windows® XP Professional and Microsoft Windows XP Home Edition

Processor ..... (GX620) Intel® 945G chipset, Intel Pentium® D processor with Dual Core architecture, Intel Pentium 4 processor with the option of implementing Hyper-Threading Technology or Celeron D® processor
(GX520) Intel 945G chipset with Intel Pentium 4 processor with Hyper-Threading Technology and Celeron D processor

Processor Features ..... (GX620) Intel Pentium D 800MHz FSB socket T with Dual Core technology XD, EM64T, 2x1MB L2 cache and EIST
Intel Pentium 4 800MHz FSB socket T with HT, XD, EM64T, 2MB L2 cache and EIST
Intel Pentium 4 800MHz FSB socket T with HT, XD, EM64T and 1MB L2 cache
Intel Celeron D 533 MHz FSB Socket T with XD & EM64T and 256KB L2 cache
(GX520) Intel Pentium 4 800MHz FSB socket T with HT, XD, EM64T and 1MB L2 cache
Intel Celeron D 533 MHz FSB Socket T with XD, EM64T and 256KB L2 cache

Memory ..... (GX620) Four DIMM slots (two DIMM slots on USFF chassis); non-ECC dual-channel shared[3] DDR2 SDRAM system memory (533MHz) up to 4GB[4]
(GX520) Two DIMM slots non-ECC dual-channel shared[3] DDR2 SDRAM system memory (400 and 533MHz)

Video Graphics Controller ..... Integrated Intel Graphics Media Accelerator 950
DVI Adapter card (GX620); 128MB ATI® Radeon® X600SE with DVI and TV-out (GX620)

Hard Drive ..... 40GB[5], 80GB[5] and 160GB[5] 7200RPM serial ATA; 250GB[5] 7200RPM serial ATA available on GX620

Network Controller ..... Broadcom® 5751 Gigabit Ethernet LAN solution 10/100/1000[2] Ethernet with Remote Wake-up and PXE support

Standard I/O Ports ..... Eight USB 2.0 (two front and six rear), USFF offers seven USB 2.0 (two front and five rear), one Ethernet (RJ45), one nine-pin serial (16550-compatible), one parallel (25-hole, bi-directional), one VGA out, (DVI-I-out on USFF)
Optional second serial port (not available on USFF), stereo line-in, microphone-in (front), speakers/line-out and headphone (front)

CHASSIS
SMALL FORM FACTOR, DESKTOP AND MINITOWER AVAILABLE

Dimensions ..... Small form factor 31.63cm x 9.26cm x 34cm
Desktop 39.59cm x 11.43cm x 34.77cm
Mini-tower 41.14cm x 18.96cm x 43.18cm
Ultra-small form factor 26.3cm x 8.9cm x 25.28cm

Power Supply ..... (GX620) Small form factor 275W; Desktop 280W; Mini-tower 305W; Ultra-small form factor 220W (External)
(GX520) Small form factor 220W; Desktop 220W; Mini-tower 230W

PERIPHERALS

Monitors ..... 15" E153FPb TFT Flat Panel, 17" E773c/s
17" E173FPb TFT Flat Panel, 17" M783
19" E193FPb TFT Flat Panel, 19" M993 UltraScan™
15" 1505FP HAS TFT Flat Panel,
UltraSharp™ 17" 1704FP TFT Flat Panel,
UltraSharp 19" 1905FP TFT Flat Panel,
UltraSharp 20" 2001FP TFT Flat Panel,
UltraSharp 20" 2005FPW TFT Flat Panel,
UltraSharp 24" 2405FPW TFT Flat Panel

All-in-one Solutions ..... UltraSharp 1706FP All-in-one (SF chassis)
UltraSharp 1906FP All-in-one (SF chassis)
(GX620) 1706FP All-in-one (USFF chassis)

Keyboard (105 Keys) ..... Dell Enhanced QuietKey™ USB, Enhanced Performance USB, Smart Card keyboard USB

Mouse ..... Dell USB two-button and Dell USB optical two-button scroll

Speakers ..... Internal Dell business audio speaker, Dell A215, Dell A425, AS500 and AS500PA sound bar available with select FP monitors

STORAGE DEVICES

Removable Media Storage Devices ... USB Floppy Drive, CD-ROM, CD-RW[#], CD-RW/DVD Combo, DVD-ROM[#] and DVD+/-RW[6]

USB Storage Keys ..... Dell USB Memory Key 128MB, 256MB and USB 2.0 full-speed-compliant and bootable

SECURITY

Security ..... Trusted Platform Module 1.2 (TPM 1.2) standard on the GX620
Chassis intrusion switch standard on GX620, optional on GX520

ENVIRONMENTAL ERGONOMICS & REGULATORY

Standards ..... TCO99, Blue Angel, Green PC, ENERGY STAR®, CECP, BSMI, C-TICK, CE, FCC, IRAM, NEMKO, NFPA 99, SABBS, SASO, TCO, TUV, UL, VCCI, USB 2.0

SERVICE & SUPPORT

Base Service ..... Three-Year Next Business Day On-Site[7]

Optional Service ..... Custom Factory Integration, Gold Technical Support (GTS), Same Day Response (12x5), On-Site Hardware Support, CompleteCare™ Accidental Damage, PC Installation Services, Dell Training, Asset Recovery Services

Dell PCs use genuine Microsoft® Windows®
www.microsoft.com/piracy/howtotell

Microsoft® Windows® xp

not available on SF or USFF

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For detailed environmental information go to:
www.dell.com/environment_datasheets

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